



December, 2012

# ENVIS Newsletter



**BIHAR ENVIS CENTRE**

***On State of Environment & Related Issues***

**Sponsored by**

**The Ministry of Environment and Forests, Govt. of India.**

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## Editorial

In continuation of our effort of generating awareness on the environmental issues, our ENVIS newsletter of month, December 2012 is before you.

Air pollution being at the centre stage these days, we have taken up information regarding chimneys/stacks, its height and its relation with pollution in the issue. Mobile phones/tower radiations being much talked about issues these days. We have tried to put available informations at one place for a better appreciation.

Hope this will be informative to the public at large.

ENVIS Coordinator

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## CONTENTS

1. All about Chimney
2. Effect of Stack Height on Transport & Dispersion of Air Pollutants
3. Height of Stacks in Industry
4. Cell Phone and Tower Radiation Pollution
5. Radio Frequency of Mobile Network and Environment
6. Permissions Required, Radiation Norms and Guidelines related to Cell Phone & Tower
7. National Ambient Air Quality Standards
8. Environmental Issues in Bihar

### **Cover Photo :**

Hon'ble Chief Minister, Bihar releasing the first issue of 'ENVIS Newsletter' on 9<sup>th</sup> August, 2012 at Patna.

# All about Chimney

## Introduction

Conducted emissions of gaseous or dust-bound pollutants are produced during numerous industrial and commercial processes, as well as with domestic heating. A large part of emissions are generated by combustion processes. The gaseous products of combustion and dust with other pollutants generated in various industrial activities are more harmful when they are at the ground level. As a precaution against harmful environmental effects or air pollution control, a set of minimum requirements for the discharge of exhaust gases & other pollutants to the outside atmosphere have been stipulated. The objective is, therefore, to get them as high into the air as possible by means of a chimney and a certain amount of buoyancy so that no harmful or damaging effects are produced. The stack or chimney or vent play an important role for the abatement and control of such air pollution emissions. Stacks are used to reduce the ground level concentration of a pollutant by emitting the process gas at great height at which the dispersion of pollutants over a greater area reduces their concentrations in ambient air to maintain the air quality in compliance with various regulatory limits.

## Types of air pollutant emission sources:

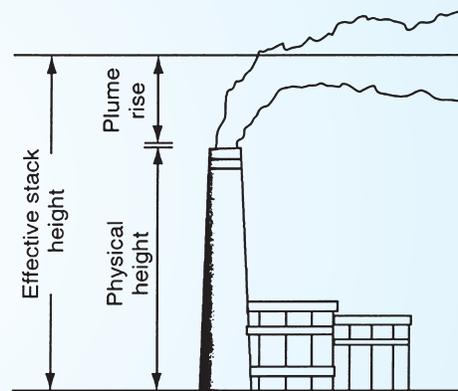
- **Point source** — A point source is a single, identifiable source of air pollutant emissions (for example, the emissions from a combustion furnace flue gas stack). Point sources are also characterized as being either elevated or at ground-level. A point source has no geometric dimensions.
- **Line sources** — A line source is one-dimensional source of air pollutant emissions (for example, the emissions from the vehicular traffic on a roadway).
- **Area source** — An area source is a two-dimensional source of diffuse air pollutant emissions (for example, the emissions from a forest fire, a landfill or the evaporated vapors from a large spill of volatile liquid).
- **Volume source** — A volume source is a three-dimensional source of diffuse air pollutant emissions. Essentially, it is an area source with a third (height) dimension (for example, the fugitive gaseous emissions from piping flanges, valves and other equipment at various heights within industrial facilities such as petroleum refineries and petrochemical plants). Another example would be the emissions from an automobile paint shop with multiple roof vents or multiple open windows.
- **Sources** may be characterized as either **stationary** or **mobile**. Flue gas stacks are examples of stationary sources and automobiles are examples of mobile sources. **Emission Point** is point of constituent emissions release into the air.

## Some important terminologies used in stack emission

- **Flue Gases:** When coal, oil, natural gas, wood or any other fuel is burnt in a stove, oven, fireplace, boiler or industrial furnace, the hot gases that are formed are referred to as flue gases. Flue gas is usually composed of carbon dioxide ( $\text{CO}_2$ ), water vapor, nitrogen, particulate matter, carbon monoxide, nitrogen oxides, sulfur oxides and excess oxygen remaining from the intake combustion air; it is generally depend upon burning fuel. These gases are generally expelled to the ambient outside air through chimneys or industrial flue gas stacks.
- **Stack or Flue Gas Stack or Chimney:** A flue gas stack is a type of chimney, a vertical pipe, channel or similar structure through which combustion product gases called flue gases are exhausted to the outside air. Chimneys are usually vertical to ensure that the gases flow

smoothly. The space inside a chimney is called a flue.

- **Chimney:**When the flue gases are exhausted from stoves, ovens, fireplaces, or other small sources within residential abodes, restaurants, hotels, or other public buildings and small commercial enterprises, their flue gas stacks are referred to as **chimney**. Industrial chimneys are commonly referred to as **flue gas stack**.
- **Flue gas stack draft (or draught):**The flue gases inside the stack are much hotter than the ambient outside air and therefore, less dense than the ambient air. That causes the bottom of the vertical column of hot flue gas to have a lower pressure than the pressure at the bottom of a corresponding column of outside air. That higher pressure outside the chimney is the driving force that moves the required combustion air into the combustion zone and also moves the flue gas up and out of the chimney. That movement or flow of combustion air and flue gas is called “**Natural Draft (or Draught)**”, “**Natural Ventilation**”, “**Chimney Effect**”, or “**Stack Effect**”. The taller the stack, the more draft (or draught) is created.
- **Induced Draft/Forced Draft:** A mechanical (induced) draft system utilizes pressure difference created by the action of a fan, blower or ejector which removes flue gases from the furnace and forces the exhaust gas up the stack. Forced Draft is obtained by forcing air into the furnace by means of a fan (FD fan). Forced draft (FD) fans supply air to the furnace, and induced draft (ID) fans remove flue gas. Typically, the FD fans control airflow, while ID Fans control furnace pressure to slightly below atmospheric pressure. A natural-draft system has no fan. An induced-draft system has a fan **after** the burner and heat exchanger but before the vent. A forced-draft system has a fan **before** the burner, heat exchanger and vent.
- **Physical Stack Height:**Actual or physical height of the stack from ground level is known as physical stack height.
- **Effective Stack Height:** The effective stack height is the sum of the physical stack height and the plume rise.



### Designing chimneys and stacks to provide the correct amount of natural draft involves many factors such as:

- The height and diameter of the stack;
- The desired amount of excess combustion air needed to assure complete combustion;
- The temperature of the flue gases leaving the combustion zone;
- The composition of the combustion flue gas, which determines the flue gas density;
- The frictional resistance to the flow of the flue gases through the chimney or stack, which will vary with the materials used to construct the chimney or stack; and
- The heat loss from the flue gases as they flow through the chimney or stack; The local atmospheric pressure of the ambient air, which is determined by the local elevation above sea level.

# Effect of Stack Height on Transport & Dispersion of Air Pollutants

## Introduction

Stacks have only one function to disperse flue gas into the atmosphere. The height of the stack or chimney is determined by several factors including: meteorological parameters, height of the nearest building or structure, prevailing wind direction, height of natural landforms, location of air intake, type of equipment draft (natural or forced), type of fuel and local and/or national ambient air quality requirements. Stack height is the key parameter which highly affects transportation and dispersion of pollutants. Several terminologies are used in determination of the stack height and its effects on pollutants dispersion.

## Important terminologies

**Air Pollution:** One or more air containments in such concentration and of such duration that they could cause injury or adversely affect human health or welfare; animal life, vegetation, or property; or even interfere with the normal use and enjoyment of animal life, vegetation, or property.

**Air Contaminant:** Particulate matter, radioactive materials, dust, fumes, gas, mist, smoke, vapor, or odor, including any combination of those items, produced by processes other than natural.

**Ambient Air:** That portion of the atmosphere (outdoor environment), external to buildings, to which the general public has access.

**Ambient Air Quality (AAQ):** Ambient air quality refers to the condition or quality of outdoor air in our surrounding environment that directly affects the health of humans and ecosystems. It is typically measured near ground level, away from direct sources of pollution.

**Air Quality Standards and Limits:** Air quality standard means such concentration of any solid, liquid or gaseous substance present in the atmosphere which is not required to exceed; and limit means the concentration of above substance (solid, liquid or gaseous) which shall not be exceeded.

**National Ambient Air Quality Standards:** The level of air quality is necessary with an adequate margin of safety to protect the public health, vegetation and property. The National Ambient Air Quality Standards (NAAQS) are standards established by the Central Pollution Control Board under the authority of the E(P) Act, 1986, that apply for outdoor air throughout the country in which ambient air quality standards for twelve pollutants (SPM-  $PM_{10}$  &  $PM_{2.5}$ ,  $SO_2$ ,  $NO_2$ ,  $O_3$ , Pb, CO,  $NH_3$ ,  $C_6H_6$ , As, Ni & Benzo(a)Pyrene) are established.

**Background Pollutant Concentrations:** Constituent pollutant concentrations present in the ambient air that are not attributed to the source or site being evaluated. It includes concentration due to natural sources, nearby sources and unidentified or possibly distant sources.

**Ground-Level Concentration:** The concentration of a pollutant in air to which a human being is normally exposed, i.e. between the ground and a height of some 2 meters above it.

**Relation between Background pollutant Concentration at ground level & AAQ standard:** The difference between the existing air pollution level (Background pollutant concentrations at ground level, which is established by using high-volume air sampling) and the ambient air quality standard is used to evaluate for the establishment of new units in the area. The emission from a new plant and chimney height must be such that:  $C_0 + C_{max} \leq \text{Ambient Air quality standard}$ ; where,  $C_0$  is the existing level of air pollution before the plant comes into operation (Background pollutant concentrations at ground level);  $C_{max}$  is the calculated (by Gaussian-Plume Model) maximum pollutant concentrations at ground level due to the new proposed plant. No plant may be set up if the existing ambient air pollution already exceeds the AAQ standard. If pollution exceeds the air quality standards in any area, it is in most cases impossible to prove that one or more specific sources are responsible.

**Carrying Capacity of Ambient Air:** The maximum number of individuals that a given environment (Ambient Air) can support without detrimental effects. Carrying capacity is defined as the environment's maximal load.

**Receptor:** A location where the public could be exposed to an air contaminant (or constituent) in the ambient air. Receptors are points, defined by the modeler, that represent physical locations at which the air dispersion models will predict ambient pollutant concentrations. Receptors are classified as industrial or sensitive receptor such as a school, residence, recreational area, hospital etc.

**Plume:** The trajectory of the movement of gases discharged from a chimney/stack is known as plume. It moves away from its source and widens because of entrainment of the surrounding fluid at its edges. Plumes are cloud-

like masses of pollutants traveling through the air under the influence of diffusion and convective mechanisms. Plumes disperse in all directions in shape, horizontal and vertical.

**Plume Rise:** Due to the initial kinetic energy of the released plume and its thermal energy, when the plume temperature is above ambient air temperature, there will be an increase in the emission height of the plume. This is known as the plume rise. Plume rise is the distance above a pollutant-emitting stack that the plume centerline will climb before leveling off horizontally or the height at which the plume becomes passive and, subsequently, follows the ambient air motion.

**Entrainment:** Atmospheric air pulled into the plume interior by mixing within the plume is called entrainment. The speed with which the process occurs is directly proportional to wind speed. Concentrations in the plume are inversely proportional to the wind speed.

**Lapse Rate:** The **lapse rate** is defined as the rate at which air temperature changes with elevation. Rate of change in temperature observed while moving upward through the Earth's atmosphere. The lapse rate is considered positive when the temperature decreases with elevation, zero when the temperature is constant with elevation, and negative when the temperature increases with elevation. Lapse rate is highly variable as are being affected by radiation, convection, and condensation; it averages about 6.5°C per kilometer (18.8°F per mile) in the lower atmosphere (troposphere).

**Inversion, Temperature Inversion & Inversion Layer:** In meteorology, an **inversion** is a deviation from the normal change of an atmospheric property with altitude. The condition when temperature actually increases with altitude is referred to as a **temperature inversion**, because it limits vertical air motion. In fact inversion allows virtually no vertical air motion. The atmospheric layer within which such a condition or temperature increase occurs is called **inversion layer**.

Normally, the air near the Earth's surface is warmer than the air above it because the atmosphere is heated from below as solar radiation warms the earth's surface, which in turn then warms the layer of the atmosphere directly above it. Thus, the atmospheric temperature normally decreases with increasing altitude. However, under certain meteorological conditions, atmospheric layers may form in which the temperature increases with increasing altitude. Such layers are called inversion layers as stated above also. When such a layer forms at the Earth's surface, it is called a **surface inversion**. When an inversion layer forms at some distance above the earth, it is called an **inversion aloft**. By definition, an inversion exists when warmer air overlies cooler air. There are four processes to produce an inversion: **a)** Inversion due to cooling of air at the surface; **b)** Inversion due to heating from above; **c)** Flow of a layer of warm air over a layer of cold air; **d)** Inversion due to flowing of cool air under warm air.

**Mixing height:** When an inversion aloft is formed, the atmospheric layer between the earth's surface and the bottom of the inversion aloft is known as the **mixing layer** and the distance between the earth's surface and the bottom of inversion aloft is known as the **mixing height**. Thus, mixing height may be defined as the plume height that thermal and/or mechanical turbulence produces before it is cooled off by colder air.

### **Plume Behaviors**

Once pollutants are released into the atmosphere they are transported by air motions which lower the air pollutant concentrations in space over a period of time. Meteorological parameters are usually used to describe this phenomenon (Plume Behavior) which include wind speed, wind direction, turbulence, mixing height, atmospheric stability, temperature and inversion. Depending on how the plant releases the exhaust, the smoke stack can develop plume behavior, which may occur under some commonly encountered meteorological conditions are - a coning plume, a fanning plume, a looping plume, a lofting plume or a fumigation.

**Coning:** A coning plume occurs under essentially neutral stability, when environmental lapse rate is equal to adiabatic lapse rate, and moderate to strong winds occur. The plume enlarges in the shape of a cone. A major part of pollution may be carried fairly far downwind before reaching ground.

**Looping:** Under super adiabatic condition, both upward and downward movement of the plume is possible. Large eddies of a strong wind cause a looping pattern. Although the large eddies tend to disperse pollutants over a wide region, high ground level concentrations may occur close to the stack.

**Fanning:** A lofting plume or a fanning plume occurs in the presence of a negative lapse rate when vertical dispersion is restricted. The pollutants disperse at the stack height, horizontally in the form of a fanning plume.

### **Transport of Pollutants, Plumes and Air Dispersion**

❖ The transport of air pollutants is largely driven by weather phenomena. Vertical air motions along with

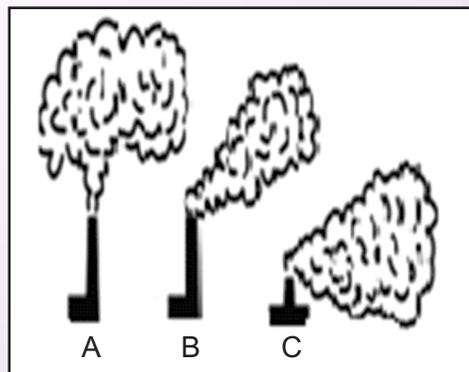
prevailing winds both dilute and disperse particle and gases emitted from any given source. On a global scale, unequal solar heating causes warm air near the equator to rise and then descend as it cools and travels toward the north and south poles. This effect alone would produce wind circulation toward the poles at high altitudes and toward the equator at low altitudes. But several other phenomena complicate the global weather picture. The earth's rotation has two effects, surface friction that drags surface air in the direction of rotation and a *Coriolis force* that, in general, turns air movement to the right in the North hemisphere and towards the left in the South hemisphere. The *Coriolis force* occurs as a consequence of the Earth's rotation. Surface characteristics (e.g., oceans and other large bodies of water Vs land areas) that modify the air temperature and moisture content, also influence large air flow pattern. Mountains, forests and even cities affect wind patterns more locally. Gases and vapors more closely follow wind patterns, but they have diffusion velocities that can cause them to spread beyond the air parcel into which they are emitted. Particles with large aerodynamic diameter-20 $\mu\text{m}$  and above have behaviors strongly influenced by gravity and by the particle's inertia. Therefore, they readily settle out of the air parcels in which they are entrained. Particles in this size regime settle out of the air at velocities that exceed 3m per hr. Thus, if such particles are emitted 1m above the earth surface they will settle to the ground in about 20 minutes, unless they encounter substantial updrafts or descending terrain. Small particle e.g., those 1 $\mu$  or smaller in diameter have settling velocities of less than a few cm per hr. Such particles can travel in the wind for more than several km before settling to the ground. Very small particles can travel thousands of km before settling out of the air.

Increasing the height of a stack will usually decrease the near-stack ground level concentration of emitted particles and gases and cause emissions to dilute and deposit further downwind. Ambient air velocity effects on stack emissions. Low wind speed tends to increase nearby ground level concentrations, but at high wind speed the additional dilution of the emission decreases downwind concentrations. As an example, if the pollutant concentration downwind from a point emission source is 10mg/m<sup>3</sup> of the air, then doubling the wind speed should result in a concentration of about 5mg/m<sup>3</sup>, or half the original concentration. Interestingly, humid air has a lower density than dry air. This is because the molecular weight of H<sub>2</sub>O vapor( 18 atomic mass units) is less than that of both N<sub>2</sub>(28 atomic mass unit) which it make up most of the air, therefore water vapor displace these heavier gases.

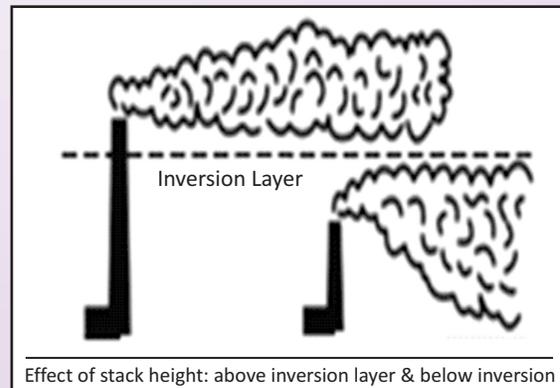
❖ **Smokestack plumes are dispersed under the influence of meteorological conditions as under:**

The figure shows the effect of wind on a plume in the normal lapse-rate case:

- A) Tall stack with no wind, the typical plume will rise and spread laterally (**coning**).
- B) In tall stack with light wind, the plume will also spread as it is blown.
- C) In short stack with light wind, the plume may touch the nearby ground, which can produce highlevels of emissions at ground level near the stack.

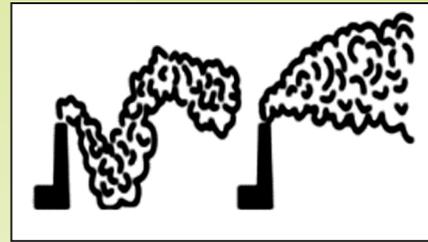


The figure demonstrates that plume behavior in an inversion condition when the smokestack is above or below the inversion height. As for the short smokestack, an emission below the inversion layer can produce substantial local ground-level concentrations. The condition of a low inversion height and an even shorter smokestack is called **trapping**



Effect of stack height: above inversion layer & below inversion

Figure shows the effect of lapse rate on smokestack plume. If the lapse rate is strong in which the decrease in temperature vs. altitude is much greater than normal, **looping** of the plume can occur, which can cause the plume to descend to the surface, rise, and descend again. If the lapse rate is weak or normal, the plume tends to remain **aloft**.

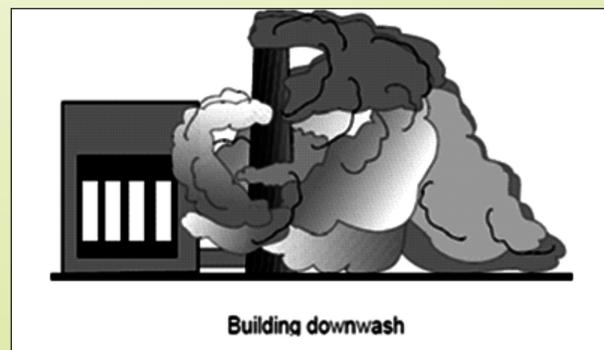
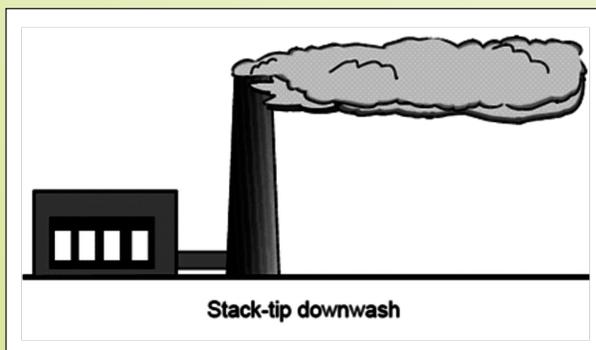


The most serious conditions, such as a short smokestack, an emission below a low inversion, and a strong lapse rate, have the potential for producing high ground level concentrations of emissions. In the ideal case the smokestack will be tall enough to allow substantial dilution of the plume before it reaches the surface.

### ❖ DOWNWASH

All large structures distort the atmosphere and interfere with wind flow to some extent. These atmospheric distortions usually take the form of wake, which consists of pocket of slower & more turbulent air. If a plume is emitted near a wake, it is usually pulled down because of the lower pressure in the wake region. This effect is termed as downwash. A wake that causes downwash usually occurs as the result of one of following three physical conditions:

- **Stack-tip downwash:** Stack-tip downwash occurs when the plume is washed out in a downward manner, creating a net increase in the ground level concentration of pollutants immediately downwind of the source. It occurs when the ratio of the stack exit velocity to wind speed is small or the stack gas exit velocity is low. In this circumstance, a considerable horizontal wind speed will create a leveling-off effect for the plume, or may cause a downwash of some or all of the plume to lower heights. This effect can be represented by the following generalized **effective stack height equation**:  $H = h_s + \Delta h + 2d_s (v_s / u - 1.5)$ ; Where  $H$ = effective stack height,  $h_s$ = physical height of the stack,  $\Delta h$  = plume rise,  $d_s$  = stack internal diameter at top,  $v_s$ = stack gas exit velocity and  $u$ = wind speed.
- **Downwash Caused by Local Topography:** Topography also influences the dispersion of air pollutants. The “topography” refers to the surface features of land, including the configuration and elevation of both man-made and natural features. Topographical features may impede the dispersion of pollutants, specially when the pollutants are released in low-lying areas. For example, large hills or mountains can change the normal wind patterns of an area. If the stack is located closely downwind of a hill, the air flowing off the hill can cause the plume (emitting from stack) to impact & downwash closer to the stack than normal.
- **Downwash Caused by nearby large structures or building (Building Downwash):** Large structures surrounding the stack also effect ambient wind conditions. As air moves over and around buildings and other structures, turbulent wakes are formed in the downwind side of the building. When stack source located within distance about five times the height of a building or structure, it may be possible for the plume to be pulled down into this wake area and then forced down to the ground much sooner than it would if a building or structure were not present. This is referred to as aerodynamic or **building downwash** of the plume and can lead to elevated pollutant concentrations immediately downwind of the source. This distance referred to as the **building's region of influence**. To take account of local building effects, models generally require information related to location of buildings/structures with respect to the stack.



## Height of Stacks in Industry

In our country environmental regulations contain strict rules for granting of consent for each individual unit with condition to comply with the emission standards based on the best available control technology. The stack is one of the easily available pollution control technologies and essential pollution control measures. The stack height plays a role in its ability to transport and disperse the pollutants at higher altitude, which helps to lower the influence of pollutant on the surrounding to meet the emission standards as well as ambient air quality standards in compliance with various regulatory limits.

Emissions from industrial stacks are regulated by Pollution Control Board to protect human and environmental health. Industries are required to obtain Environmental Clearance/NOC/Consent from the regulatory agencies to emit into the atmosphere and to demonstrate their compliance with regulations. In the process of compliance of the statutory environmental regulations the stack height recommendations are based on the following to assess the impact of stack or point source emission:

1. “Dispersion Models”;
2. Stack Height prescribed in the provisions of the **Environment(Protection) Rules,1986**;and
3. As recommended by **Central Pollution Control Board (CPCB)**.

### Stack Height Recommendations based on “Dispersion Model”

Air dispersion model is defined as a quantitative or mathematical representation or simulation which attempts to describe the characteristics or relationships of physical events of environment in an area. Air dispersion modeling is used to know how air pollutants disperse in the ambient atmosphere and to estimate or to predict the downwind concentration of air pollutants at particular distances from emission sources. Evaluations of pollution control strategies (stack height etc) and their effects are performed with the help of such modeling to improve ambient air quality levels, and for determining the impact of pollutants emitted into the environment. It is performed with computer programs. Several air pollution dispersion models are currently available but **Gaussian-Plume Models** are widely used, well understood, easy to apply and approved by CPCB also and on the basis of modeling results stack height with other measures are recommended. On the basis of modeling the recommended stack height ensures that pollutants would be dispersed over a wider area to meet legal or other safety requirements. Maximum and worst ground level concentrations in an area due to the proposed new plant may be derived. Dispersion Modeling is also routinely used in Environmental Impact Assessment, Risk Analysis and Emergency Planning.

### Mathematical Formula of Effective Stack Height and Plume Rise

Effective Stack Height (**H**) = Physical Stack Height (**h<sub>s</sub>**) + Plume Rise (**Δh**).

Numerous formula for calculation of plume rise have been developed between 1960 and 2000 which are **Brigg's equations; Carson-Moses Equation; Holland Formula and Concawe Formula**. Brigg's equation is the most realistic, is preferred and is the most complex as follows:

$$\Delta h = \frac{1.6F^{\frac{1}{3}}x^{\frac{2}{3}}}{\bar{u}}$$
 ; where, F = Buoyancy Flux,  $\bar{u}$  = average wind speed, x= downwind distance from the stack/ source,  $F = \frac{g}{\bar{u}}v\left(\frac{T_s - T_a}{T_s}\right)$ ; Where, g = acceleration due to gravity(9.8 m/s<sup>2</sup>), V = volumetric flow rate of stack gas, T<sub>s</sub> = temperature of stack gas, T<sub>a</sub> = temperature of ambient air.

### Stack Height Regulations under the Environmental (Protection) Rules, 1986 [Schedule-I]

Industry specific stack heights have been prescribed which are as under:

#### A.FOR THERMAL POWER PLANTS

(I)

Steam Generation Capacity	Coal Consumed	Stack height
Less than 2 ton/hr	Less than 8.5 MT/day	2.5 times the neighbouring building height or 9 meters (whichever is more)
More than 2 ton/hr to 5 ton/hr	8.5 MT/day to 21 MT/day	12 m
More than 5 ton/hr to 10 ton/hr	21 MT/day to 42 MT/day	15 m
More than 10 ton/hr	42 MT/day to 64 MT/day	18 m
More than 15 ton/hr to 20 ton/hr	64 MT/day to 104 MT/day	21 m
More than 20 ton/hr to 25 ton/hr	104 MT/day to 105 MT/day	24 m

More than 25 ton/hr to 30 ton/hr	105 MT/day to 126 MT/day	27 m
More than 30 ton/hr	More than 126 MT/day	30 m or using formula $H=14(Q)^{0.3}$ (Whichever is more)

**Note: Q= Emission rate of SO<sub>2</sub> in kg/hr and H= Stack height in meters.**

**(II) Minimum Stack Height Requirements based on power generation**

Power generation less than 200 MW / 210 MW capacity.	$H = 14 (Q)^{0.3}$ ; where Q = Emission rate of SO <sub>2</sub> in Kg/hr H = Stack height in m.
Power generation 200 MW / 210 MW and more capacity but less than 500 MW	220 m
Power generation capacity 500 MW and above	275 m

**Note:**

- No standards for sulphur dioxide emission has been prescribed, the control being effected through the height of the stack by using formula:  $H = 14 (Q)^{0.3}$
- Applicable for **industrial furnace** and **kiln** applications based on coal usage.
- Minimum height of stack in all cases shall be 9.0 M (30 ft) or as calculated by the relevant formula whichever is more.

**B. Stack Height for Small Boilers (schedule-I, Sr. No- 70)**

For the small boilers using coal or liquid fuels, the required stack height with the boiler shall be calculated by using the formula,  $H=14(Q)^{0.3}$ ; Where, H = Total stack height in meters from the ground level; and Q=SO<sub>2</sub> emission rate in kg/hr.

In no case the stack height shall be less than 11 metres. Where providing all stacks are not feasible by using above formula the limit of 400 mg/Nm<sup>3</sup> for SO<sub>2</sub> emission shall be met by providing necessary control equipment with a minimum stack height of 11 metres.

**C. For Ceramic Industry**

**Capacity:**

Up to 5T/day	Stack Height	A Hood should be provided with a stack of 30 meter height from ground level (including Kiln height)
Above 5T/day	-Do-	$H= 14 (Q)^{0.3}$ Where Q is emission rate of SO <sub>2</sub> in kg/hr and H=Stack height in m.

**D. Stack heights of following units have also been prescribed in the schedule-I of the Rules:**

- a) Brick Kilns; b) Grain Processing, Flour Mills, Paddy Processing, Pulse Making or Grinding Mills; c) Foundries; d) Glass Industry; e) Lime Kiln; f) Beehive Hard Coke; g) Coal Briquette Industry; h) Refractory Industry; i) Lead Glass.

**Stack Height Requirements as Recommended by CPCB [Emission Regulations Part- I & II]**

**GUIDELINES FOR MINIMUM STACK HEIGHT**

1.

**Plant Type**

**Stack Height**

For all plants except Thermal Power Plant

30 m

- 2. For plants where the sulphur dioxide emission is estimated as Q (kg/hr) the stack height, H in metres is given by  $H = 14 (Q)^{0.3}$
- 3. For plants where the particulate matter emission is estimated as Q(tones/hr) the stack height, H in metres is given by  $H = 74 (Q)^{0.27}$
- 4. By using the formula given in 2 or 3 above, if the stack height arrived is more than 30 m then higher stack height should be used.
- 5. Stack Height Requirement for sulphur dioxide control in thermal power plant is same as above **A (II)**.

**Stack Height Recommendations by CPCB (Emission on regulations Part-IV)**

- The stack height calculation for coal fired boilers is given by the formula( derived from the Gaussian Plume Model and also published in Emission Regulations Parts I and II) as:  $H=14(Q)^{0.3}$ , where H is the physical height of the stack in metre and Q is the emission of sulfur dioxide in kg/hr.

- The prescribed stack height corresponding to steam generation capacity and coal consumption is same as above: **A(I) for thermal power plants.**
- Minimum height of stack in all cases shall be 9.0 m (30 ft) or as calculated by the relevant formula, whichever is more.
- For boilers using, liquid fuels such as furnace oil or LSHS, the control would be through the stack and its height is calculated by  $H=14(Q)^{0.3}$  as above.

### Boiler Classification (Source: CPCB Emission Regulations Part-IV):

Boilers are classified according to their steam generation capacity. The relation between the boiler and the industry size is given below:

Category	Steam Generation Capacity	Size of Industry	Recommended Control Device
I	Less than 2 ton/hr	Very small manufacturers	Cyclones
II	2 to 15 ton/hr	Package boiler range for small scale industries.	Multiclones
III	More than 15 ton/hr	Site-erected boiler for medium scale industries.	Bagfilters

### Assumptions

- The sulphur dioxide emitted from the stacks would be proportional to the coal consumption.
- 1 MW of electricity generation is equivalent to 7.0 ton/hr of steam generation.
- 1 ton/hr of steam generation requires 5.0 MT of coal per day.
- 1 MW of electricity generation requires 30 MT of pulverized coal per day.

### Sulfur Content of Various Fuels in India (source- cpcb)

Experience has shown that the sulfur contents on average, for various fuels available in India, are as follows:

Type of Fuel	'S' Content in %
Light Diesel Oil(LDO)	1.80
High Speed Diesel	1.00
Kerosene	0.25
Furnace Oil	3.00 - 4.00
LPG	0.10
Coal	0.50

### Sulfur Content in Solid Fuel

Type of Fuel	'S' Content in %
Coal(Jharkhand)	Normally 0.2 to 0.4
Assam coals	6.00
Rice Husk	0.00
Paddy Straw	0.17
Wheat Straw	0.31
Bagasse	0.00
Garbage	0.5
Wood	0.00

### Sulfur Content in Bulk/Industrial Liquid Fuel

Type of Fuel	Source: Indian Oil Corporation				Source: Bharat Petroleum	
	Grade LV	Grade MV1	Grade MV2	Grade HV	Grade MV2	Grade HV
Furnace Oil Sulfur, total% wt. max	3.5	4.0	4.0	4.5	4.0	4.5
Light Diesel Oil(LDO) Total sulfur content, percent by mass. max	HSD(High Speed Diesel) 0.50		LDO(Light Diesel Oil) 0.25		HSD	LDO
Low Sulfur Heavy Stock (LSHS) Sulfur % wt.	-				max. 0.25	

### Other References to Estimate Stack Height

- **Height of Stack [As per Bureau of Indian Standards: IS 6533(Part 1): 1989; Reaffirmed 2001]**

Tall stacks are necessary to disperse pollutants into the atmosphere in order to maintain an acceptable air quality standard at the ground level. Height of stack is a function of various factors, for example, mass rate of emission, efflux velocity, temperature of effluent, topographical conditions, meteorological conditions of the area where stack is located and lastly, the air quality standards that must be maintained. Based on these parameters, assuming a relatively flat terrain and temperature of effluent equal to the atmospheric temperature, the height of the stack is determined from the following formula:

$$H = \left( \frac{AMFD}{8CV} \right)^{3/4}$$
 Where:  $H$  = calculated height of stack in m,  $A$  = coefficient of temperature gradient of atmosphere responsible for horizontal and vertical mixing of plume (For tropical zone  $A = 280$ , and for semi-tropical zone  $A = 240$ ),  $M$  = estimated mass rate of emission of pollutant in g/s,  $F$  = dimensionless coefficient of rate of precipitation (For gases,  $F = 1$ , and for dust  $F = 2$ , if efficiency of dust

catching is above 90 percent; 2.5, if efficiency of dust catching is 75 to 90 percent; 3.0, if efficiency of dust catching is below 75 percent);  $C$  = maximum permissible ground level concentration of pollutant in  $\text{mg}/\text{m}^3$  at standard temperature and pressure (may be taken as  $0.5 \text{ mg}/\text{m}^3$  unless otherwise specified in relevant health standards),  $V$  = Estimated volume rates of emission of total flue gases,  $\text{m}^3/\text{sec}$ , and  $D$  = diameter of stack at the exit of the Chimney in m.

#### Limitations of the Formula

1. The formula is applicable only in cases of tall stacks, the plume which is free from interference with the air currents produced by nearby tall buildings.
2. The formula assumes only a single source of air pollution. Where several stacks are located close to each other, the value of  $H$  obtained from the formula has to be increased such that the total ground level concentration at a place from all the stacks for any particular pollutant does not exceed the air quality standards.
3. The formula assumes the temperature of the gases to be equal to the atmospheric temperature. The resultant height of stack is slightly on the higher side.
4. The maximum concentration as calculated above is reached at a distance  $X$  m from the chimney, approximately given by  $X = 20H$ , where  $H$  is the height of the chimney in m above the ground level.

#### SUMMARY

- Stack height is estimated by above options and taller stack should be preferred to achieve emission norms and national ambient air quality standard. The height of the stack shall not be less than the height of the zone of turbulent air layers formed due to uneven heights of buildings near the stack.
- Air pollution control considerations are the principal determinant for stack heights in modern power plants. While fly ash may be effectively removed from flue gas by mechanical collectors (ESPs), no practical means other than stacks have been found acceptable for deposition of sulfur dioxide formed in coal combustion. For dispersal of  $\text{SO}_2$ , minimum stack height is prescribed by the formula:  $H = 14(Q)^{0.3}$ . In the worst case Flue Gas Desulphurization (FGD) system is recommended.
- It is working rule that for the small power plant the stack height may be estimated as at least  $2\frac{1}{2}$  times the height of the powerhouse or other nearby structures.
- Based on Indian Boiler Regulation code (IBR code), which refers that if the sulfur content in fuel is  $x\%$ , then 1 kg of fuel will give  $2(x\%) \text{ SO}_2$ , this may be helpful in stack height estimation.
- Assam coals contain about 6 % sulphur mostly in organic combination. The flue gases resulting from the combustion of such type of coal contain on an average 0.3 to 0.5 %  $\text{SO}_2$  by volume. Assam coals are used in the state of Bihar also by various units and mostly by Brick Kilns.
- Particulate matter emissions are the air pollutant most frequently associated with wood/rice husk/bagasse fired boilers. Sulfur dioxide emissions may become significant if large amounts of fossil fuels are co-burned with these biomass fuels. In overall comparison of boiler emissions fired by wood/rice husk/bagasse shows that it has lower  $\text{SO}_2$  and net greenhouse gas emissions than coal and oil fired of similar size. Nitrogen oxide emission rates are close to the emission rates from coal and oil, whereas particulate matter, CO and total organic compound emissions are higher than coal or oil fired for similar size of equipment.
- Approximately 75% of the total particulate emissions from wood-fired boilers are below  $2.5 \mu\text{m}$  and 67% are below  $1 \mu\text{m}$ . Particulate matter less than  $2.5 \mu\text{m}$  diameter is more injurious to health.
- The phenomenon induced by the density difference between a hot and cold air column that creates a natural flow through a chimney is called stack effect or chimney effect. Flow of gases in furnaces, stacks and other equipments operating at atmospheric pressures involve small difference in pressures and this small pressure difference is conveniently handled in terms of "draft". Draft ( $d$ ) at any point in the gas flow system is:  $d = [\text{Absolute pressure in the systems} - \text{absolute pressure of the surrounding atmosphere at the same level}]$ . Two factors affect the amount of draft produced by a stack:
  1. **Heat:** the hotter the gases in the chimney compared to the air outside, the stronger the draft.
  2. **Height:** the taller the stack, the more draft it will produce at a given temperature difference.
 Stack effect is the factor to determine whether induced draft is required or not.
- The common coals used in industry are bituminous coal and gradation of the coal is based on its calorific value. Biomass (rice husk/bagasse/agro waste/municipal solid waste) is used as fuel in the modern concept of power generation from renewable source of energy.

- Furnace Oil is used as fuel for power generation in DG Sets, in boilers/ furnaces/ any other heaters / feedstock in Fertilizer Plants. HSD is normally used as a fuel in medium and high speed compression ignition engines (operating) above 750 RPM in commercial vehicles, stationary diesel engines, locomotives and pumps etc. LDO is used in lower RPM engines. It is used in lift irrigation pump-sets, DG Sets and as a fuel in certain boilers and furnaces. LSHS is residual fuel and has special advantage of having low Sulphur content and high calorific value. It is used in lieu of furnace oil in the same applications where furnace oil is suitable. Kerosene is used as illuminant in domestic lamps & as a fuel in small generator sets, cooking stoves etc.

## National Ambient Air Quality Standards (NAAQS)

[Notification dated 18<sup>th</sup> November, 2009]

S. No	Pollutants	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
			Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (notified by Central Government)	
1.	Sulphur Dioxide (SO <sub>2</sub> ), µg/m <sup>3</sup>	Annual *	50	20	1. Improved West and Gaeke 2. Ultraviolet Fluorescence
		24 Hour **	80	80	
2.	Nitrogen Dioxide (NO <sub>2</sub> ), µg/m <sup>3</sup>	Annual *	40	30	1. Modified Jacob & Hochheiser (Na-Arsenite) 2. Chemiluminescence
		24 Hours**	80	80	
3.	Particulate Matter (Size<10 µm) or PM <sub>10</sub> µg/m <sup>3</sup>	Annual *	60	60	1. Gravimetric 2. TOEM 3. Beta attenuation
		24 Hours**	100	100	
4.	Particulate Matter (Size<2.5 µm) or PM <sub>2.5</sub> µg/m <sup>3</sup>	Annual *	40	40	1. Gravimetric 2. TOEM 3. Beta attenuation
		24 Hours**	60	60	
5.	Ozone (O <sub>3</sub> ), µg/m <sup>3</sup>	8 hours **	100	100	1. UV photometric 2. Chemiluminescence 3. Chemical Method
		1 hours**	180	180	
6.	Lead (Pb), µg/m <sup>3</sup>	Annual *	0.50	0.50	1. AAS/ICP Method after sampling using EPM 2000 or equivalent filter paper 2. ED-XRF using Teflon filter
		24 Hour**	1.0	1.0	
7.	Carbon Monoxide (CO), mg/m <sup>3</sup>	8 Hours **	02	02	Non dispersive Infra Red (NDIR) Spectroscopy
		1 Hour**	04	04	
8.	Ammonia (NH <sub>3</sub> ), µg/m <sup>3</sup>	Annual *	100	100	1. Chemiluminescence 2. Indophenol blue method
		24 Hour**	400	400	
9.	Benzene (C <sub>6</sub> H <sub>6</sub> ), µg/m <sup>3</sup>	Annual *	05	05	1. Gas chromatography based continuous analyzer 2. Adsorption and Desorption followed by GC analysis
10.	Benzo(a)Pyrene (BaP)-particulate phase only, ng/m <sup>3</sup>	Annual *	01	01	Solvent extraction followed by HPLC/GC analysis
11.	Arsenic (As), ng/m <sup>3</sup>	Annual *	06	06	AAS/ICP Method after sampling using EPM 2000 or equivalent filter paper
12.	Nickel (Ni), ng/m <sup>3</sup>	Annual *	20	20	AAS/ICP Method after sampling using EPM 2000 or equivalent filter paper

\* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

\*\* 24 Hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

# Cell Phone and Tower Radiation Pollution

## Background

In the last decade, cell phone subscribers have increased exponentially throughout the country and now, our country is the world's largest market of mobile-voice services after China. Bihar has also registered maximum increase in annual mobile phone service subscribers with making a growth of more than 88%. Still, the growth of mobile phone subscribers and its usage is expanding rapidly throughout the state. According to the India Census Report 2011, there are about 51.6 % households having subscribers (about more than 46.5 million) to cell phone services in the state. Not only is this number increasing among adults but also among children and teenagers. In some parts of the state mobile phones are the only phones available. Now, it has become so useful business tool and social accessory for Bihar's society that some people can neither write his name nor can read fluently but they keep two mobile connections. Due to the exponential increase in cell phone usage, the demand for cell phone towers has increased accordingly. With so many cell phone users, especially children and teenagers, and a rise in cell phone towers, people are discussing with questions about associated health hazards due to exposure from radiations of mobile handsets and towers.

One of the main reasons of cell phones and health issues is because cell phones emit radio frequency energy (or radio waves), a form of electromagnetic radiation, which is known to produce heat. Exposure to high levels of radio frequency radiation is harmful as radio frequency energy can heat biological tissue rapidly and thus may have effect on human body. Scientists and public health experts are extensively engaged in determining the potential health hazard of cell phone radiation.

## Cell Phone

A small wireless electronic device used for telecommunications, that has at least the same functions of a standard wired telephone, often referred to as **mobile phone, cellular phone or cell phone**. Mobile phone device is a radio transmitter and receiver. Generally they have more functions than traditional land lines. A cell phone requires a subscription to a service provider that enables a user to communicate almost anywhere in the world by connecting with a wireless communications network through radio wave. Most mobile phones provide voice communications, Short Message Service (SMS), Multimedia Message Service (MMS) and Internet Services such as web browsing and e-mail. Today, cell phones are becoming capable of doing almost anything a computer is capable of doing. It works by sending and receiving wireless radio signals with a nearby base station (sometimes called a "cell") which connects it to the main phone network. When a call is placed from a cellular phone, a signal is sent from the cell phone antenna to that cell's base station antenna. The base station responds to the cellular phone signal by assigning the phone an available radio frequency (RF) channel. When the RF channel is assigned, modulated radio signals are simultaneously received and transmitted, allowing voice information to be carried between the cell phone and the base. The base station transfers the call to a switching center, where the call can be transferred to a local telephone carrier or another cell phone.

A cell phone contains just a few individual parts: An amazing circuit board containing the brain of the phone; an antenna; a liquid crystal display (LCD); a keyboard; a microphone; a speaker and a battery. **SIM Cards** - Subscriber Identity Module cards are small printed circuit boards that contain individual cell phone account and user information and that are inserted into GSM phones.

## Cell Phone Tower

A cell phone tower is typically a steel pole or lattice structure that rises hundreds of feet into the air and is made of electronic equipment and antennas that send and receive radio frequency signals. Modern tower is having more than one different cell phone service providers sharing of antenna on the same structure. More than 13,000 mobile towers of various telecom companies have been installed across the state in a haphazard way in the absence of specific rules and norms, earlier.

There are following brands of mobile-phone service provider in the state of Bihar at present: BSNL, Reliance Communication, Airtel, Aircell, Idea, Vodafone, Tata indicom, Uninor and TATA Docomo. They are providing mobile phone services based on GSM(Global System for Mobile Communications), CDMA(Code Division Multiple Access) & 3G(Third-Generation Mobile Phone) technology as frequency band allotted by the regulatory authority.

## Various terminologies related to mobile network radiation:

### Radiation, Wave and Frequency

Energy emitted from a source is generally referred to as radiation. Examples include heat or light from the sun, microwaves from an oven, X rays from an X-ray tube, and gamma rays from radioactive elements. Radiation is energy that travels and spreads out as it goes. In the general sense, heat and light are also a form of radiation. Natural radiations are everywhere in our environment and come from space and from naturally occurring materials contained in the earth and in living things. Man and all life forms on earth have evolved in a radiation environment and are being exposed to natural radiation.

Wave is a disturbance or variation that transfers radiation energy progressively from point to point in a medium and that may take the form of an elastic deformation or of a variation of pressure, electric or magnetic intensity, electric potential, or temperature. Wave travels through a medium and the particles in the medium do not travel with the wave. Waves have two basic properties called “**wavelength**” and “**frequency**”. The wavelength is the distance between two successive wave tops or peaks. The frequency measures the rate at which the waves move. The number of oscillations of a wave in one second is called frequency and it is expressed in the unit **Hz (hertz)**. Frequency and wavelength of a wave are inversely proportional to each other.

Broadly speaking, radiation is a way in which energy moves from one place to another and it (radiation) consists of waves--water waves, sound waves, light waves, heat waves and as such. Radiation cannot be detected by our senses. We need to depend on indirect means for detection. Instruments are used to detect and measure radiation levels.

**Note:  $10^6$  Hertz (Hz) =  $10^3$  Kilohertz (KHz) = 1 Megahertz (MHz) = .001 Gigahertz (GHz)**

### Electric Field, Magnetic Field

Electric fields come from the voltage that is used to make electric current flow in a wire. The voltage is like the water pressure which makes water flow in a plumbing system, and the electric current is like the water flow. Electric fields get bigger as the voltage increases. Electric field occurs around a conductor, such as power transmission line, electric cable/wire when voltage is put in. The strength/ intensity of electric field (E) is expressed with the unit **Volt per meter (V/m)**. When there is an electric current in a conductor, a magnetic field is generated around it. Strength of the magnetic field (H) is expressed with the unit **Ampere per meter (A/m)**. Electric field depend on the magnitude of the voltage and distance from the source. Similarly, magnetic field strength depend on the magnitude of the current and distance from the source.

### Electromagnetic Field (EMF)

Electric field and magnetic field together are called “electro-magnetic field”. When electric and magnetic fields are alternately generated and propagated through space together, this wave is called electro-magnetic wave and the strength of EMF is expressed with the units **Watt per square meter ( $W/m^2$ )**. The electromagnetic field (i.e. EMF) includes electric and magnetic fields from the electricity supply, radio waves from TV, radio devices, medical devices, mobile phones, radar and satellite communications. The electromagnetic field (EMF) as a pollution is called 'electro-smog'.

Since the rate at which energy emanating from a fixed constant source of electromagnetic radiation and passes through a surface at a distance **d** from the source is proportional to  $1/d^2$ , which is known as the Inverse Square Law. Therefore, the electro-magnetic field [energy flow measured in Watts per square metre ( $W/m^2$ )] weakens very quickly as it moves away from the antenna. It is reduced to 1/4 when the distance from antenna doubles and 1/9 when distance is tripled and so on.

## Electromagnetic Radiation (EMR)

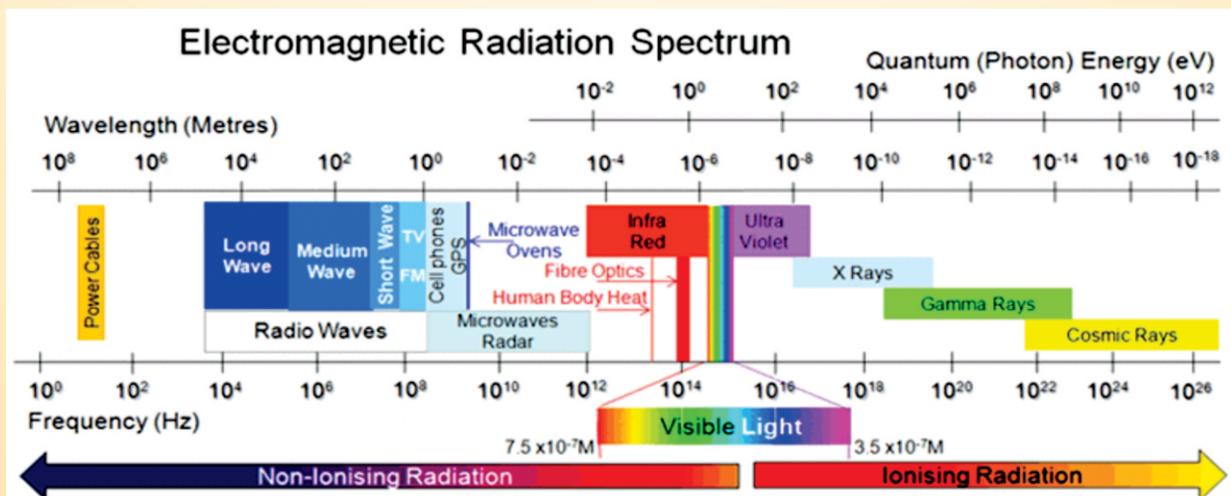
Electromagnetic Radiation consists of electric and magnetic energy waves moving together through space at the speed of light, which can be characterized in terms of a wavelength and a frequency. Technically, all electromagnetic waves are the same type, the only difference between them is their frequency or wavelength -- that is, how fast they vibrate. These are the names we use from low frequency to high, such as radio waves, microwaves, infrared, visible light, ultra-violet light, x-rays, gamma rays, and cosmic rays. The only difference between the various types of electromagnetic radiation is the amount of energy found in the photons. Radio waves have photons with low energies, microwaves have a little more energy than radio waves, infrared has still more, then visible, ultraviolet, X-rays, and ... the most energetic of all ... gamma-rays. EM waves having wavelength as small as  $10^{-15}$  m to as large as 30 km.

The main source of electromagnetic radiation in the atmosphere is the Sun, which sends electromagnetic waves of different wavelengths towards the earth. Electromagnetic radiation is a wonderful thing. It brings us heat and lights up our day, it brings us radio and television and carries our telephone conversations. It brings us the Sun's energy which is needed by all plants for photosynthesis and growth. It brings warmth to the inhabitants of the earth's animal kingdom. It can be found in nature or be man-made.

## Electromagnetic (EM) Spectrum

The electromagnetic spectrum is the combination of all types of electromagnetic radiation. We artificially divide the spectrum into categories based on use of frequency/wave range, effects and the causes of the radiation. It is just a name that scientists give a bunch of types of radiation when they talk about them as a group. We can call this spectrum as frequency spectrum also. The frequency spectrum is shared by civil, government and military users of all nations according to International Telecommunications Union (ITU) radio regulations. For telecommunication purposes, the usable frequency spectrum (or radio frequency spectrum) range from 3Hz (extremely low frequencies) to 300 GHz (extremely high frequencies). This range from 3Hz to 300 GHz has been split into a continuous group of frequencies and each group is called a band or frequency band. Each band has a defined upper and lower frequency limit and difference between them is called bandwidth. The bandwidth is the amount of space available to transfer data. Higher the bandwidth, faster the data transfer. It is generally considered that frequency between 3kHz to 300GHz is in the RF band and various regulatory bodies around the world divide up this portion of EM spectrum arbitrary for various radio services.

Here are the different types of radiation in the EM spectrum, in order from lowest energy to highest:



The National Frequency Allocation Plan (NFAP) forms the basis for development and manufacturing of wireless equipment and spectrum utilization in the country.

## Types of Radiation

**There are two types of radiation: Non-Ionizing radiation & Ionizing radiation**

Radiation that has enough energy to move atoms in a molecule around or cause them to vibrate, but not enough to remove electrons, is referred to as "**non-ionizing radiation**" (**NIR**). Non-ionizing radiations encompass the long wavelength ( $> 100 \text{ nm}$ ), low photon energy ( $< 12.4 \text{ eV}$ ) **portion of the electromagnetic spectrum, from 1 Hz to  $3 \times 10^{15} \text{ Hz}$**  and this include the narrow visible light region also. The ability of NIR to penetrate the human body, the sites of absorption, and the subsequent health effects are very much frequency ( $f$ ) dependant.

On the other hand, ionizing radiations, with wavelengths less than  $100 \text{ nm}$ , constitute the high photon energy portion of the electromagnetic spectrum, are termed as **ionising radiations**, since they have enough energy to remove tightly bound electrons from atoms, thus creating ions. This is the type of radiation that people usually think of as 'radiation'. We take advantage of its properties to generate nuclear power, to kill cancer cells (or in other medical treatment), and in many manufacturing processes.

## Radio waves, Microwaves and Infrared

All electromagnetic waves of different wavelengths travel with same speed in vacuum or air which is same as the speed of light i.e.,  $3 \times 10^8 \text{ ms}^{-1}$  and described by their wavelengths, energy and frequency. The speed ( $c$ ), frequency ( $f$ ) and wavelength ( $\lambda$ ) of electromagnetic waves are related as:  **$c = f \lambda$** . They exhibit the properties of reflection and refraction. In refraction, when an EM wave passes from one medium to the other, its speed and wavelength changes, but its frequency remains unchanged.

In communication system generally we use radio waves, microwaves and infrared radiations as carrier for transfer of voice, data and signal from one place to another, therefore, these waves can be categorized into three broad groups:

### **Radio waves      Microwaves      Infrared radiations**

It is actually the behavior of the waves rather than the frequencies that determines the classification of wireless transmission. There is no clear difference between radio waves and microwaves.

**Radio waves:** In the cellular communication system radio waves are used for transmitting information between mobile phones and antennas. **Advantage of radio waves signals:** Radio waves are normally **omnidirectional** (all ways). When an antenna transmits radio waves, they are propagated in all directions. This means that the sending and receiving antennas do not have to be aligned. The omnidirectional characteristics of radio waves make them useful for multicasting, in which there is one sender but many receivers. Our AM and FM radio stations, cordless phones and televisions are examples of multicasting.

**Disadvantage of radio waves:** Radio waves transmitted by one antenna are susceptible to interference by another antenna that is sending signals of the same frequency or band.

**Microwaves:** Microwaves are also used in mobile phone networks for transmitting information between two antennas and waves ranging in frequencies between  $1 \text{ GHz}$  and  $300 \text{ GHz}$  are normally called microwaves. Unlike radio waves, microwaves are **unidirectional** (travel in straight line as light), in which the sending and receiving antennas need to be aligned. Microwaves propagation is line-of-sight, therefore, towers with

mounted antennas need to be in direct sight of each other. Due to the unidirectional property of microwaves, a pair of antennas can be placed aligned together without interfering with another pair of antennas using the same frequency. High-frequency microwaves cannot penetrate walls. This is why receiving antennas cannot be placed inside buildings. **Microwaves** are often used in the media, satellite communication, radar used by aircraft, ships and weather forecasters, by internet service providers to transmit data from one point to another. Microwave oven uses microwaves to heat and cook our food. But the most common use of microwaves are still in communications.

**Infrared (or Heat) radiations:** It does not use in mobile communication networks. They travel in straight line as light and have frequencies between 300 GHz to 400 THz. They are used for short-range communication. Infrared is used in devices such as the mouse, wireless keyboard and printers. Infrared signals have high frequencies and cannot penetrate walls. Due to its short-range communication system, the use of an infrared communication system in one room will not be affected by the system in the next room. This is why we use an infrared in TV remote control and other gadgets. Also used for therapeutic purposes by doctors. Infrared signals cannot be used for long distance communication. In addition, we cannot use infrared waves outside a building because sun's rays contain infrared waves that can interfere with communication.

### **Radio Frequency (RF) and Microwave**

Radio waves and microwaves are forms of electromagnetic energy that are collectively described by the term “**radiofrequency**” or **RF**. RF emissions and associated phenomena can be discussed in terms of “energy”, “power”, “radiation” or “field”. Electromagnetic radiation can best be described as waves of electric and magnetic energy moving together through space. Radio Frequency is also used to describe the number of times per second or oscillation of an electromagnetic radiation. Anything between 3Hz and 300GHz is referred to as RF waves, but they are subdivided and depend on the actual frequency. Lower frequencies are referred to as radio waves while higher frequencies are called microwaves. Microwave is just a subset of the RF range.

### **Units for radio frequency (RF) and microwave power measurements**

Power is a measure of energy per unit time and it is typically measured in watts - this is a energy transfer at the rate of one Joule per second. Kilowatts ( $10^3$  watts), or megawatts ( $10^6$  watts) are used in some large power installations, whereas other applications have much lower levels - mille watts ( $10^3$  watts), or microwatts ( $10^{-6}$  watts) may be found. In some instances power may be specified in terms of dBW or dBm. These use the logarithmic decibel scale but related to a given power level. In itself a decibel is not an absolute level. It is purely a comparison between two levels, and on its own it cannot be used to measure an absolute level. The quantities of dBm and dBW are the most commonly used.

**dBm** - This is a power expressed in decibels relative to one mille watt.

**dBW** - This is a power expressed in decibels relative to one watt.

From this it can be seen that a level of 10 dBm is ten dB above one mille watt, i.e. 10 mW. Similarly a power level of 20 dBW is 100 times that of one watt, i.e. 100 watts.

### **Specific Absorption Rate (SAR)**

Two quantities are of interest in considering health effects from electromagnetic radiation. The first is called the “**power density**”, the other is called the “**specific absorption rate**”.

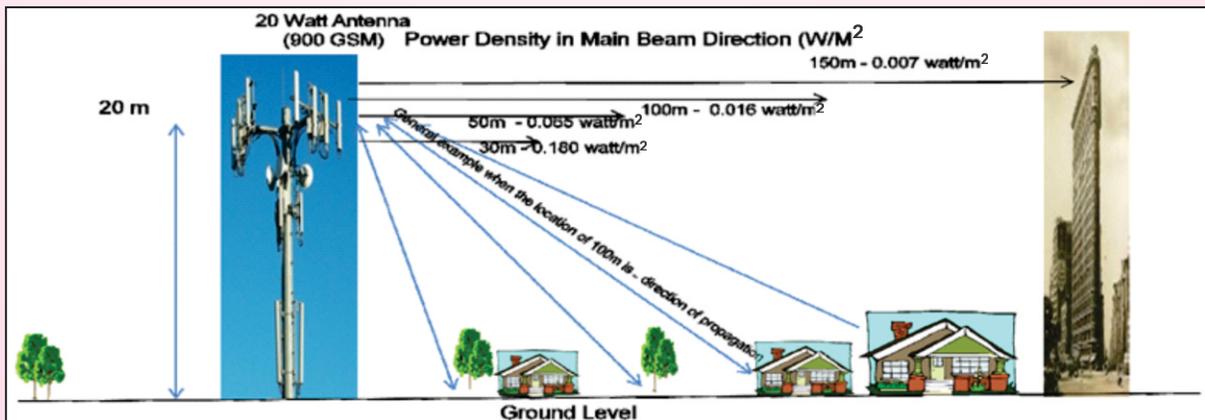
**Power density:** Power density, typically measured in transmitted radio waves, is defined as the amount of power per unit volume, usually expressed in units of watts per square meter. In the case of radio waves, that power travels equally in all directions like a bubble, and estimations assume that nothing interferes with the transfer of that wave and a constant amount is lost with distance. Power Density  $P_d$  at a distance  $R$  is equal to  $\frac{P_t \times G_t}{4\pi R^2}$ ; where,  $P_t$  = Transmitted power in watts;  $G_t$  Gain of transmitting antenna;  $R$  = Distance from the antenna in meters.

**SAR:** This is a measure of how much electromagnetic radiation is actually absorbed in the human body, and is measured per unit mass of the region that is being irradiated. SAR is the rate at which Radio humar Frequency energy is absorbed in the human body over a given time and expressed as the **power absorbed per unit mass {watts per kilo gram (W/kg)} of tissue**. For example, if the SAR is equal to 1 mille-watt per gram, this means that every gram of the part of the body being irradiated is subject to energy absorption of 1 mille-joule per second. This measurement is used to determine whether a mobile phone complies with safety norms/guidelines. Every model of mobile handset has specific SAR value. However, the actual SAR level of an operating device can be well below this value. This is because the phone is designed to use the minimum power required to reach the network. Therefore, the closer you are to a base station, the more likely it is that the actual SAR level will be lower.

### Radiation from Mobile Handsets and Tower Antenna

The electromagnetic fields emission from mobile handsets and antenna are at relatively low end of electromagnetic spectrum and the energy carried by them or the energy level associated with radio frequency and microwave radiation, are not great enough to cause the ionization of atoms and molecules. The Radio Frequency (RF) energy is, therefore, a non ionizing radiation like radiation from visible light, infra-red radiation, and other forms of electromagnetic radiation with relatively low frequencies. Thus, cell phone is having very, very low level of radio frequency energy emission and the type of energy emitted is non-ionizing.

Electromagnetic radiation from a source/tower antenna spreads in a surrounding area and creates Electro-magnetic Field (EMF). The intensity of EMF is strongest at the source and becomes weaker and weaker as distance increases. Thus the distance plays a vital role. Time is also a key factor towards how much exposure a person receives. An example is shown below:



# Radio Frequency of Mobile Network and Environment

## Background

We are exposed to both natural and man-made radiation. The electromagnetic radiation may occur naturally such as ultraviolet light from the sun and as made by lightning etc. Major contribution of radiation exposure sources to the population are the natural background and medical exposures. In India, more than 95% of the radiation is caused by the natural background radiation sources. Thus, we all are in the midst of a radiation environment, however low it may be, and it is not possible to avoid radiation exposure from natural sources altogether. Therefore, it is needed to control the radiation from man-made sources to levels as low as is reasonably achievable.

Radiation emitted from Cell Phones, Cell Phone Towers, Wi-Fi, TV and FM Towers, Microwaves Ovens, Remote Control etc all are electromagnetic radiations (EMR) and termed as radio waves/microwaves/infrared and are man-made.

## Mobile handsets & Radio waves

As per Department of Telecommunications (DoT), Ministry of Communications & Information Technology, Govt. of India, a mobile handset or a cellular phone is a low-power, two way radio. It contains a transmitter and a receiver. It emits electromagnetic / RF radiation to transmit information to the base station and it also acts like a receiver of information. Radio signals or radiation in a mobile phone are generated in the transmitter and emitted through its antenna in all directions and a proportion of it is directed to the human body. The radiation emitted by the antenna is not sufficient to cause any significant heating of tissues in the ear or head, although a rise in skin temperature may occur as a result of placing the mobile phone too close against the ear or head for a long time. This is due to insulation of the phone, contact with the screen, lack of ventilation between the ear and the phone, and the energy generated by electronic components. 3G mobile phones operate at lower power levels than both GSM and CDMA handsets.

## Cellular phone tower & Radio waves

Mobile phone base stations are radio transmitter with antennas mounted on either transmission towers or roof tops on buildings. The antennas need to be located at optimum locations and heights so they can adequately cover the area. Antenna position usually range in height from 50-200 feet. When a person makes a cell phone call, a signal is sent from the mobile phone's antenna to the nearest base station antenna. The base station responds to this signal by assigning it an available radiofrequency channel. RF waves transfer the information to the base station. The voice/data signals are then sent to a switching center, which transfers the call to its destination. The voice signals are then relayed back and forth during the call.

**In India mobile phones operate in the frequency range(or antennas on cell tower transmit in the frequency range) of :**

- 869 - 890 MHz (CDMA): 2G Systems-newer/developing/secure/with or without SIM cards
- 935-960 MHz (GSM 900):2G Systems-GSM = older/more supported/more users/SIM cards for easy phone transferring.
- 1805 – 1880 MHz (GSM 1800)
- 2110 – 2170 MHz (3G): Voice and Video calls, TV, Internet, email, Mapping and GPS applications, high speed.

Every antenna on cell phone tower radiates electro-magnetic power. Cell phone tower is being used by a number of operators, more the number of antennas; more is the power intensity in the nearby area. The power level near towers is higher & as we move away, it reduces with distance. It is reduced to 1/4 when the distance from antenna doubles, and 1/9 when distance is tripled and so on.

## Radio Waves and Human Body

All living systems are made up of cells. Human body has about 1,00,000 billion cells. Most cells undergo division cyclically. Body metabolism ensures a close balance between production and loss of cells by elimination. When radiation passes through the body, it breaks up some of the molecules in the cells. The body's natural mechanism can repair and restore the original shape of such broken molecules. At low levels of radiation exposure the repair mechanism is almost always effective. Very rarely, this repair action may result in the broken molecules joining together in wrong order. Unrepaired molecules may persist and lead to adverse effects in the long run, if the exposure to radiation is moderately high.

Radio frequency emissions can produce both thermal and non-thermal effects. **Thermal effect** is caused by a rise in temperature due to the absorption of energy produced from electromagnetic field. When using a mobile phone, most of the heating effect will occur at the surface of the head then causing the skin temperature to increase by a fraction of a degree. Biological effects that result from heating of tissues by RF radiation are referred to as 'thermal' effects. **Non-thermal effects** could be reinterpreted as a normal cellular response to an increase in temperature.

Much of the current debate is about relatively low levels of exposure to RF radiation from mobile phones and base stations. As reported by some scientists the Radio Frequency Radiation (RFR) exposure from both mobile phones and mobile towers may have possible thermal/non-thermal effects caused by holding mobile phones close to the body. More the use of mobile phone, higher will be the temperature increase of ear lobes. Whereas, some research focusing on mobile telephony over the last two decades has shown no conclusive/convincing scientific evidence of adverse health effects caused by RF radiation from mobile network.

According to DoT, mobile communication networks use radio frequency fall under the category of non-ionization radiation, which does not disturb the cell structure of human body.

In view of the several experts, more research is required before we draw any definitive conclusions about safe levels of cell phone radiation since pollution from EMRs being a relatively new environmental issue. As the cause and the effect have not yet been established. Hence, we may have to adopt precautionary principles.

## Microwave Heating Concept

- 4.2 KW (42000 W) of microwaves power raises temperature of 1 liter of water by 1°C in 1 second. In energy absorption term, 4.2 KW-sec microwave energy will increase the temperature of 1 litre by 1°C.
- In a microwave oven, temperature of one cup of water increases from 30°C to 100°C in approx. 70 seconds with 500 W of microwave power. With 1 W power (same as output power of cell phones), temperature will increase by 1°C in 500 seconds.
- Temp. of ear lobes increases by approx. 1°C when cell phone is used for approx. 20 minutes.

## Possible Impacts of Communication Towers on Wildlife Including Birds and Bees (By MoEF)

An expert committee to Study the Possible Impacts of Communication Towers on Wildlife including Birds and Bees was constituted on 30<sup>th</sup> August, 2010 by Ministry of Environment and Forests(MoEF), Govt. of India. Several recommendations have been put forward to the Govt. by the committee which include: EMF should be recognized as a pollutant, regular auditing of EMF in ecologically sensitive areas, mandatory provisions for site clearance of mobile tower location with prior public consultation, awareness drive for general people by media and regional languages etc.

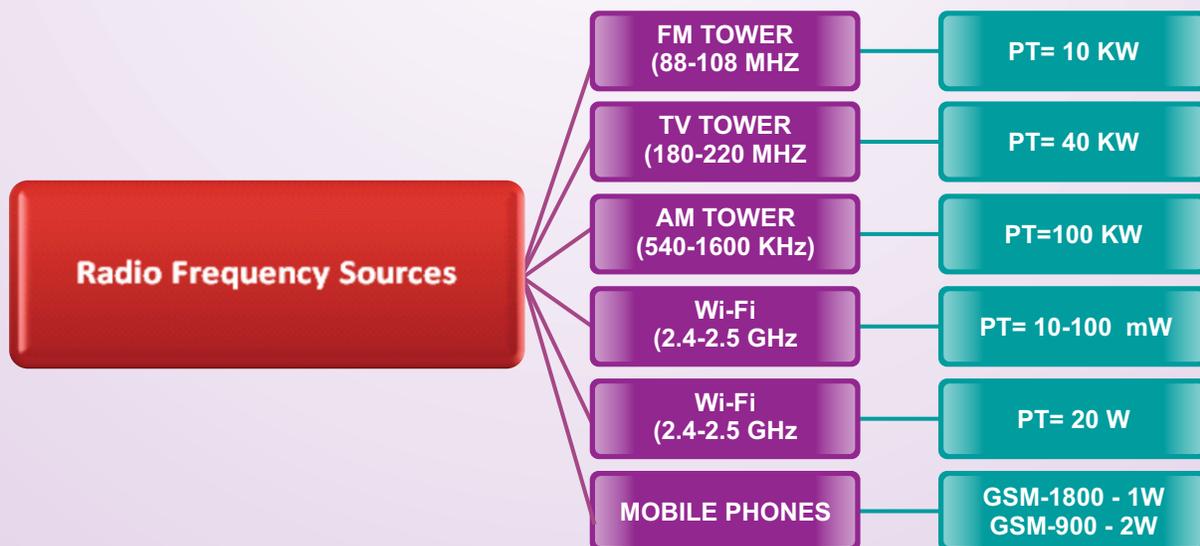
The Committee studied all the peer articles/ journals published on the impact of radiations on wildlife throughout the world and compiled them. The review of existing literature shows that the Electro Magnetic Radiations (EMRs) are interfering with the biological systems in more ways than one. There had already been some warning bells sounded in the case of bees and birds, which probably heralds the seriousness of this issue and indicates the vulnerability of other species as well. A vast majority of scientific literature published across the world indicate deleterious effects of EMFs in various other species too. In spite of the recent studies indicating possible harmful impact of EMF on several species, there are no long-term data available on the environmental impacts of EMRs as of now. Studies on impact of cell phone towers and EMR on birds and other wildlife are almost non-existent in India. Moreover, pollution from EMRs being a relatively new environmental issue, there is a lack of established standard procedures and protocols to study and monitor the EMF impacts especially among wildlife, which often make the comparative evaluations between studies difficult.

The population of many species such as honey bees, which is one of the most important pollinator has seen a drastic population drop. Unfortunately we do not have much data about the effects of EMR available for most of our free-living floral and faunal species in India. Available information from the country on the subject of EMF impacts is restricted to few reports from honey-bees, which are not representative of the real life situations or natural levels of EMF exposure. Therefore, there is an urgent need to do further research in this area before it would be too late.

## Scientific Background on the Environmental Issues

Because the EMR pollution being relatively recent in origin and lately being recognized as pollutant coupled with its expected long-term impacts and lack of data on its effect on organisms, the real impacts of these pollutants are not yet fully documented in the scientific literature. Most of the short-term studies primarily looking into the thermal impacts of EMR exposure on biological systems have neither succeeded to detect any statistically significant changes in the biological processes nor could prove any acute change in health conditions at the present background levels of exposures.

### SOURCES OF RADIO FREQUENCY



## Permissions Required, Radiation Norms and Guidelines related to Cell Phone & Tower

As of now, there are no conclusive reports that radiation emitted from mobile phones and cell towers cause immediate harms. However, it is better to be safe and take enough precaution from mobile network radiation. Therefore, we need to have rules and regulations for mobile handset and cell phone towers in order to keep the human exposure to these radiations within limits. The International Standards Organizations have developed certain limits. These limits have been adopted in India and notified by the Govt.

These rules, regulations & guidelines made and limits adopted take care of safety for all population due to the radiations taking place in all the frequency bands used by telecom service providers.

### Permissions Required from Central Authority

The service providers have to obtain site clearance from central authority (DoT) for installation of mobile towers for each and every site from the point of view of environmental effects, interference with other wireless operators, aviation hazard and obstruction to any other existing microwaves links.

### Permissions Required from State & Local Authorities

Before installation of mobile towers the telecom service providers are required to obtain necessary permission from state/local authorities also. The permission/site clearance is issued without prejudice to applicable by-laws, rules and regulations of local bodies such as Block/Municipal Corporation/Gram Panchayat etc.

The Urban Development and Housing Department, Govt. of Bihar vide their Ref.No.585, UD & HD, Dated: 21.02.2012 has notified “**BIHAR COMMUNICATION TOWERS AND RELATED STRUCTURE RULES, 2012**” and is effective from date of notification.

### Rule 5: Registration with Municipality

Any operator, who has already erected in past or intends to erect any communication tower shall have to get registered from concern Municipality and have to produce certificate from concerned authority that the noise generated from the electrical equipments is within the limits fixed from time to time by Environment and Forests Ministry, Govt. of India, and Bihar State Pollution Control Board.

### Rule 7: Location

Location of communication towers is governed by radio frequency system and operators shall avoid residential areas for erection of the same. The location shall be decided on the following grounds:-

- a. First preference shall be given to the location of tower in the open areas away from residential locations.
- b. Erection of tower shall not be allowed within a radius of 100 meter from school, college and hospital.
- c. The above guidelines shall be applicable for all new installations after these Rules come into effect.

### Rule 8: Installations

- (1) In order to avoid any eventuality due to thunder storm, lightning conductors have to installed.
- (2) Generator set installed at the tower site to cater to the power requirements of the antenna shall conform to the noise and emission norms prescribed by the Bihar State Pollution Control Board.

## Rule 9: Set Backs of Tower

- (1) The area equivalent to height of tower shall be left as set back around it.
- (2) The distance of tower from electric line or pole or tower there of shall not be less than height of tower plus requisite distance from respective high tension or low tension line.

## Rule 12: Penalty

- (1) If an operator violates any provision of these Rules it shall be liable to be punished with fine up to Rs.5,000/- (five thousand) and his communication tower shall be vsealed, seized and the operator may also be asked to remove the tower/antenna.

## Consent for DG Sets used by Mobile Towers

Operators are using DG Sets to power to mobile phone transmission towers, specially in rural areas, where power is a major problem. They (Tower service providers) have to obtain "Consent to Establish"(CTE) and "Consent to Operate"(CTO) from Bihar State Pollution Control Board under the provisions of The Air (Prevention & Control of Pollution) Act,1981 and have to comply with the provisions of The Noise Pollution (Regulation & Control) Rules,2000 including the norms and guidelines made by the CPCB for DG Sets.

In future, it is expected that the government will make it mandatory for mobile phone towers to be powered by solar energy, to cut pollution and diesel consumption in the country and to encourage use of renewable energy under the Green Telecommunications scheme which will reduce the contribution of telecom sector's carbon footprint also.

## Mobile phones and towers radiation norms in India

The WHO (World Health Organization) had declared that microwave radiation from mobile phones can increase the possibility of cancer. After rapid growth of mobile phones and towers, the associated radiation hazards became important issues for the country. Then the Indian Govt. has started monitoring of telecom operators to provide better quality services that are also ecologically safe. Before 2008, the Indian Govt. had not adopted any standards for safe exposure from mobile phone and mobile towers. In 2008, India adopted radiation norms specified by **ICNIRP (International Commission on Non-Ionizing Radiation Protection)**. The ICNIRP works closely with World Health Organization to assess health effects of non-ionizing radiations and to develop international guidelines on limits to exposure and protection measures. Not all standards and guidelines throughout the world have recommended the same limits for exposure. But the ICNIRP standards are considered to be among the best in the world and had been adopted by over 90% countries worldwide.

## SAR value for Mobile Phones

Previously, Dept. of Telecommunications (DoT), Ministry of Communications & IT, Govt of India had set standard level of SAR for mobile handsets as 2.0 W/kg averaged over 10 grams of human tissues. Viewing the growing network of mobile towers, telecom players and mobile users, the DoT has decided to revise the radiation guidelines. In January, 2012 the Central Govt. (DoT) has ordered to mobile manufacturing companies to follow the revised standard level of SAR which has been clarified in August 2012. As per Office Memorandum of DoT all the new design of mobile handsets shall comply with the SAR value of 1.6 W/kg averaged over 1 gram of human tissues w.e.f. 1<sup>st</sup> Sept. 2012. The mobile handsets with existing designs which are compliant with 2.0 W/kg averaged over 10 gram of human tissues, will continue to co-exist up to 31<sup>st</sup> August 2013. From 1<sup>st</sup> Sept. 2013, only the mobile handsets with revised SAR value of 1.6 W/kg averaged over 1 gram of human tissues would be permitted to be manufactured or imported in India for domestic market. For calculating SAR the averaging time is taken to be 6 minutes for all tissues. The DoT has permitted the manufacturer one year more to phase out old phones by August 2013.

As per notification of the DoT, mobile phone manufacturers will also have to display the SAR value on the handset and inform the consumer while selling. The manufacturers in India will provide self-declaration of SAR value of handsets.

Actually the SAR limit is based on 6 minutes per day usage. It has a safety margin of 3 to 4, so a person should not use cell phone for more than 18 to 24 minutes per day.

## Cell Phone Towers (EMF Radiation Norms)

DoT is responsible for regulating the EMF radiation from Base Transmitting Stations (BTS) towers and State Government, Municipal Corporations, Local Bodies regulate the installation of towers as per their building bylaws. DoT has taken the following steps for regulating the EMF radiation from BTS towers to safeguard the public health:

In 2008, Government of India (DoT) adopted the guidelines developed by the International Commission on Non-ionizing Radiation Protection (ICNIRP) for Electromagnetic radiation from mobile towers and revised in Dec.2011/April 2012; which are as under:

**As per revised limits, service providers have to lower the mobile towers EMF exposure limits to 1/10<sup>th</sup> of the existing prescribed limit w.e.f. 01.09.2012.**

Type of Exposure	Effective Date	Frequency Range	E-Field Strength(V/m)	H-Field Strength(A/m)	Power Density(W/sq.m)
General Public	Nov.2008	400 MHz to 2000 MHz	$1.375 f^{1/2}$	$0.003 f^{1/2}$	$f/200$
		2 GHz to 300 GHz	61	0.16	10
	01.09.2012	400 MHz to 2000 MHz	$0.434 f^{1/2}$	$0.0011 f^{1/2}$	$f/2000$
		2 GHz to 300 GHz	19.29	0.05	1

**(f: is the frequency of operation in MHz; E: Electric Field Strength and H: Magnetic Field Strength)**

Since, the cellular GSM services are being operated at 900 MHz and 1800 MHz frequency band in India, the new permissible Power Density is  $0.45 \left( \frac{900}{2000} = 0.45 \right)$  W/sq.m for 900 MHz and similarly 0.9 W/sq.m for 1800 MHz.

The service provider in India will provide self-declaration of compliance of revised EMF norms and the Telecom Enforcement Resource & Monitoring (TERM) cell under the DoT will conduct random audits of the self certification furnished by the service providers. A penalty of Rs. 5 lac will be liable to be levied per tower per service provider for non-compliance of EMF standards.

## Precautionary Guidelines for mobile users

**(Issued by the Dept. of Telecommunications (DoT), Ministry of Communications & IT, Govt of India)**

Mobile users are advised to take precautionary measures while using a mobile handset as:

1. Keep distance – Hold the cell phone away from body to the extent possible.
2. Use a headset (wired or Bluetooth) to keep the handset away from your head.
3. Do not press the phone handset against your head. Radio Frequency (RF) energy is inversely proportional to the square of the distance from the source -- being very close increases energy absorption much more.
4. Limit the length of mobile calls.
5. Use text as compared to voice wherever possible.
6. Put the cell phone on speaker mode.
7. If the radio signal is weak, a mobile phone will increase its transmission power. Find a strong signal and avoid movement – Use your phone where reception is good.
8. Metal & water are good conductors of radio waves so avoid using a mobile phone while wearing metal-framed glasses or having wet hair.
9. Let the call connect before putting the handset on your ear or start speaking and listening – A mobile phone first makes the communication at higher power and then reduces power to an adequate level. More power is radiated during call connecting time.
10. If you have a choice, use a landline (wired) phone, not a mobile phone.

11. When your phone is ON, don't carry it in chest/breast or pants pocket. When a mobile phone is ON, it automatically transmits at high power every one or two minutes to check (poll) the network.
12. Reduce mobile phone use by children as a younger person will likely have a longer lifetime exposure to radiation from cell phones.
13. People having active medical implants should preferably keep the cell phone at least 15 cm away from the implant.

**While Purchasing a Mobile Handset check the SAR value of the mobile phone. It can be searched on internet if its model number & make is known.**

### **Myths and Facts (Issued by DoT)**

**Various Myths about Mobile Handsets & Mobile base stations:**

<b>Myths</b>	<b>Facts</b>
Mobile phone use cause headaches.	Headaches are not related to Mobile phone use and there is no scientific evidence.
It is safer using a mobile phone in a car as the car shields from the radiation.	The RF radiation is increased by Mobile phones when used in a car to overcome the shielding.
Mobile phones cause brain cancer to the people who use it.	There is no scientific evidence that Mobile Phone can cause brain cancer.
Mobile Base stations are dangerous and one should have distance from it.	It is the antenna from which we should keep distance not from tower and that too if we are positioned facing antenna at comparable height. At the ground level, the intensity of RF radiation from base station is much less.
Nobody is investigating the health effects of RF radiation.	The World Health Organization, many national & international organizations and independent expert groups are coordinating to investigate health effects of RF radiation

### **Guidelines to issue of Clearance for Installation of Mobile Towers (Issued by DoT)**

**The following points are to be verified by the local body / State Government while considering to issue of clearance for installation of mobile towers:**

1. Copy of Access Service License / IP Registration Certificate from Department of Telecommunications.
2. Copy of SACFA(Standing Advisory Committee on Frequency Allocation of DoT) clearance for the said location issued by WPC Wing of Department of Telecom.
3. Other clearance at State / Local authority level:
  - i) Copy of clearance from Pollution Control Board for DG Sets.
  - ii) Copy of clearance from Fire Safety Department, if applicable.
  - iii) Copy of clearance from State Environment & Forest Dept. where necessary.
  - iv) Copy of NOC from Building Owner.
  - v) Nominal one time Administrative Fee as may be decided by the Local body to recover its costs o the issue of permission for installation of Tower.
  - vi) Electricity connection may be provided to BTS site on priority.
4. BTS Tower Details:
  - i) Data Sheet
    - a. Name of Service/Infrastructure Provider
    - b. Location
    - c. Tower Reference:
      - i) Height, ii) Weight iii) Ground/Roof Top, iv) Number of antennas planned on tower.

- ii) Copy of structural stability certificate for ground based BTS.

OR

In case of roof top BTS towers, structural stability certificate for the building based on written approvals of authorized Chartered Structural Engineer (local bodies), Central Building Research Institute (CBRI), Roorkee or reputed Engineering College like IIT, NIIT etc.

- iii) Avoid Base Station Antennas in narrow lanes ( $\leq 5$  mt.)  
 iv) In respect of roof top towers with multiple antennas, the roof top usage desirable to be totally restricted.  
 v) In case of both ground based towers & roof top towers, there shall be no nearby buildings right front of the antenna with height comparable to the lowest antenna on tower at a distance threshold as specified below:

S.No.	Number of Multiple antennas	Building/ Structure distance from the antenna (safe distance) (in mtrs)
1	2	35
2	4	45
3	6	55
4	8	65
5	10	70
6	12	75

5. Formation of State and District Telecom Committees for review of all Telecom Infrastructure related issues at State/ District Level.

**Note:** All radiation related technical details are being dealt by TERM cell of DOT.

### Regulatory Activities

- The enforcement of latest Radiation Standards in respect of Electro Magnetic Radiations (EMR) for mobile handsets and towers that came into effect from 1<sup>st</sup> September 2012 is to be regulated by the Department of Telecommunications, Govt. of India;
- State Govt., Municipal Corporations, Local Bodies regulate the installation of towers as per their building bylaws;
- Telecom Engineering Centre (TEC), the technical arm of the DoT, prepared and issued Standard Test Procedure for measurement of EMF level from BTSs in accordance with new standard;
- Telecom Enforcement Resource & Monitoring (TERM) Cell of DoT have been entrusted with the job of conducting test audit of radiation by BTSs towers. The respective TERM Cell shall carry out test audit of the BTS sites on random basis and on all cases where there is a public complaint. **Address of respective TERM Cell of Bihar Circle is "DDG", Telecom Enforcement Resources & Monitoring (TERM) Cell, Bihar, Department of Telecommunications (Ministry of Communications and Information Technology), 7th Floor, R-Block, Telephone Bhawan, Patna-800001.**
- Outsourcing for EMF radiation measurement for BTS towers is also being considered by DoT.
- If a site fails to meet the EMR criterion on testing, there is a provision of levying a penalty of Rs. 5 Lac per BTS per service provider. Service providers must meet the criterion within one month of the report of TERM cell in such cases, after which the site will be shut down;
- SAR Test Laboratory is being set up in the TEC for testing of SAR value of mobile handsets imported/manufactured in India; and
- Mobile network radiation related complain may be send to the respective **TERM Cell of DoT.**

**Please refer to the original documents for correctness**

# ENVIRONMENTAL ISSUES IN BIHAR



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