



Telecom Regulatory Authority of India



Information paper

On

**Effects of Electromagnetic Field Radiation from
Mobile Towers and Handsets**

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Introduction

1. In the last decade, the Indian telecom sector in general and mobile telephony in particular has witnessed phenomenal growth. As on May 2014, of the 938 million connections in the country, 910 million are wireless. The popularity of the cell phone and wireless communication devices has resulted in a proliferation of cell towers across the country.
2. There has been growing public concern on possible adverse health effects due to Electro-magnetic field (EMF) Radiation from mobile towers and mobile handsets. Over the past few years, a number of health activists and resident organisations have started opposing the erection of telecom towers on rooftops of houses and in densely populated areas, claiming that radiation from such installations causes serious health risks.
3. There have been several studies suggesting either the presence or absence of risk to human beings from EMF radiation. The main areas of concern are the radiation emitted by the base transceiver stations (BTS) and mobile handsets. Concerns have also been raised that continuous exposure to EMF radiation emanating from telecom towers causes harmful thermal and non-thermal health effects. The effects of exposure to EMF have created an active scientific debate among the research agencies across the globe.
4. This paper seeks to clear the air and apprise all stakeholders about EMF radiation. It elaborates the various aspects of radiations emanating from mobile towers and mobile handsets including the norms prescribed by various international bodies. The paper also contains a write-up on sources of exposure, effects of Electro-magnetic (EM) exposure on humans, absorption of energy from EM fields and International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for

Emissions from Base Stations. The paper also has information on various studies published on effects of EMF radiations and stands taken by various individuals/ bodies.

Disclaimer :

The views expressed and data provided in the studies are of the respective authors and are not endorsed by TRAI. TRAI assumes no responsibility of the correctness or otherwise of these studies.

Chapter-I

Electro Magnetic field Radiation

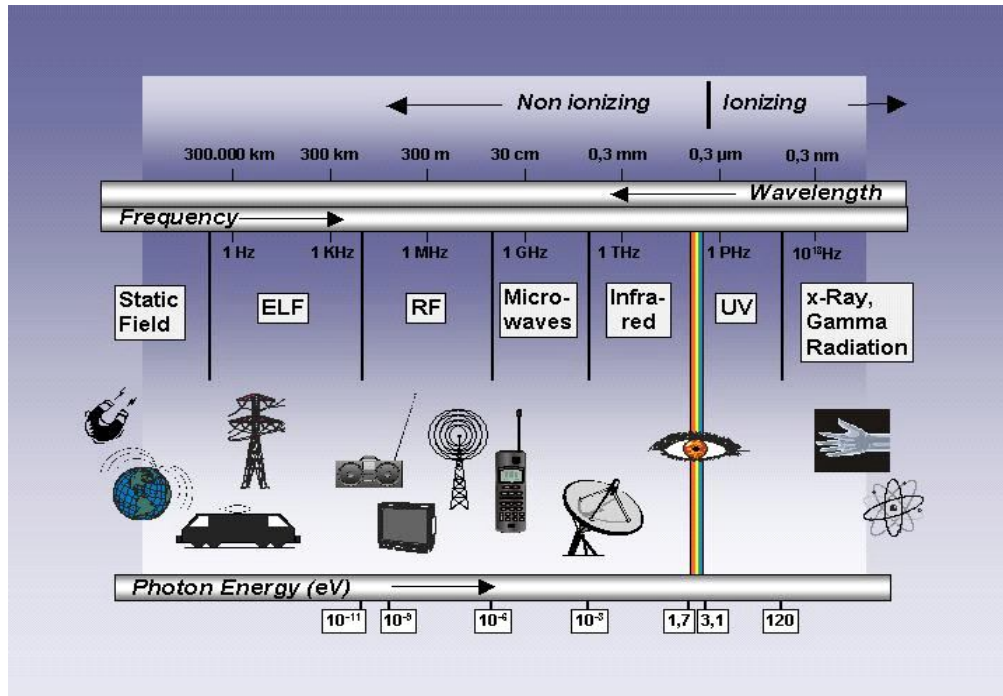
1.1 Electromagnetic field (EMF) radiation is the flow of photons through space. Each photon contains a certain amount of energy, and the different types of radiations are defined by the amount of energy found in the photons. The electromagnetic spectrum is the range of all types of EM radiation. X-rays used in hospitals or the radio waves from a radio station are all part of this spectrum.

Uses of Electromagnetic Radiation

1.2 Apart from the use in telephony, some other important uses of electromagnetic radiation as shown in figure 1.1 below, in our day to day life are as follows:

- Conversion of electromagnetic radiation from Sun (solar energy) to chemical energy (food) by plants through the process of photosynthesis.
- X-ray used for bone structure imaging at hospitals.
- X-ray used in Security Scanner at Airports and shopping malls.
- Microwave used in microwave ovens and radars.
- Radio waves used in radio and television broadcasts.
- Visible light used for normal vision.
- Infra-red waves used in night vision goggles and in TV remote controls.

Figure 1.1: Complete Electromagnetic Spectrum



1.3 The most common sources of exposure as shown in table 1.1 below, include the FM/AM radio, TV transmission, Cellular networks using GSM, CDMA, WLAN, Bluetooth, Zigbee¹, WiFi and WiMax technologies, which occupy the VHF, UHF, L, and S band of frequencies. The effects due to FM, AM and TV transmissions are localized to the areas around the location of towers and the Bluetooth, Zigbee applications operate at low power levels.

¹ ZigBee is an IEEE 802.15 standard, used to create personal area networks built from small, low-power digital radios.

Table1.1: EMF SOURCES

Sl. No.	EMF Source	Operating Frequency	Transmission Power	Number
1.	AM/FM Tower	540 KHz-108 MHz	1 KW – 30 KW	380
2.	TV Tower	48 MHz – 814 MHz	10 – 500 Watt	1201
3.	Wi-Fi	2.4 – 2.5 GHz	10 – 100 mW	
4.	Cell Towers	800, 900, 1800, 2100, 2300 MHz	20 W	~ 5 lakh
5.	Mobile Phones	GSM-1800/CDMA GSM-900	1 W 2 W	900+ Million

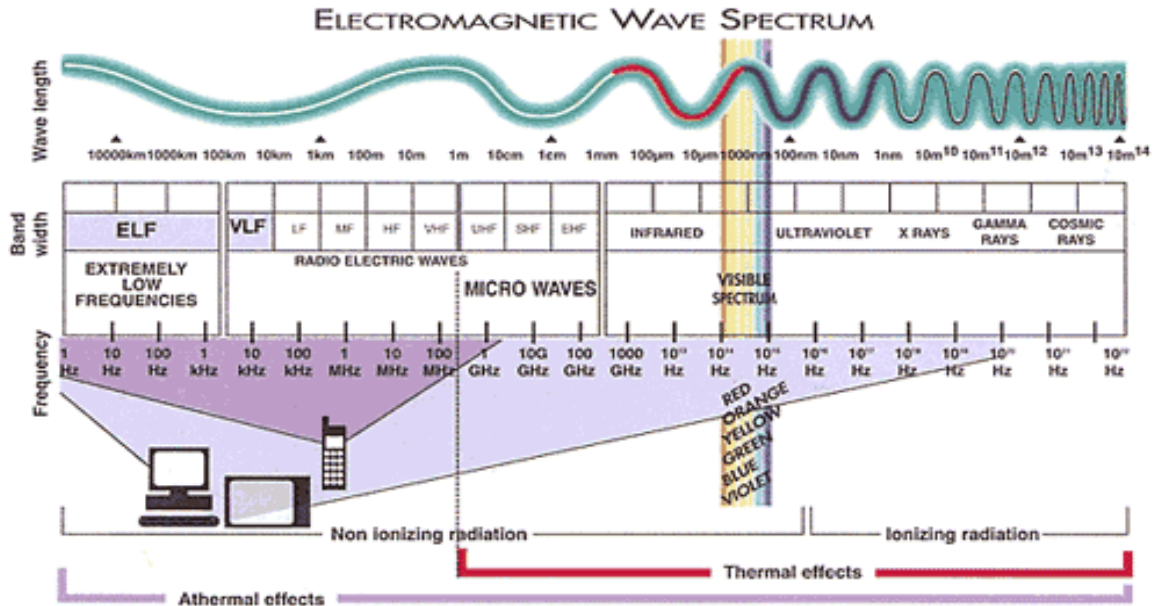
Types of EMF radiation

1.4 EMF radiations are divided into two categories, ionizing and non-ionizing, depending on frequency and the power level.

Ionizing radiation is electromagnetic radiation whose waves contain energy sufficient to overcome the binding energy of electrons in atoms or molecules, thus creating ions. e.g. Ultraviolet rays, X-rays , gamma rays and cosmic rays as shown in figure 1.2 below.

Non-ionizing radiation refers to any type of electromagnetic radiation that does not carry enough energy per quantum to ionize atoms or molecules. e.g. low frequency radiations like radio waves, microwaves, and infrared radiations as shown in figure 1.2 below.

Figure 1.2: Types of EMF Radiations



1.5 EM emissions in the frequency range of 1 Hz to 1THz(1000 GHz) are termed as non-ionizing and do not have enough energy to alter the chemical bonds of the human body. EMF health effects related to the non-ionizing radiation include tissue heating at levels above limits. EM emissions at frequencies above 1 THz are termed as ionizing and have enough potential to alter the chemical bonds of human tissue and resulting in serious genetic damage on prolonged exposure.

Effect of Ionization

1.6 As some of the radiations can ionize atoms/molecules, they do have an adverse effect on the living organisms. They can break chemical bonds and damage vital molecules. If such damage is minor, cells may be able to repair themselves, otherwise cell death may occur. If the damage is at a higher rate, dead cells cannot be replaced quickly enough.

Effects of EMF exposure on human health

1.7 Effects of EMF radiation can be studied in two ways i.e. bio-effects and health effects: -

1. Bio-effects are measurable responses to a stimulus or to a change in the atmosphere and are not necessarily harmful to our health. Biological effects can be two types i.e. Thermal and Non-Thermal effects.

Thermal Effects:-

- Refers to the heat generated due to absorption of EMF radiation.
- While using a cell phone, most of the heating effect occurs at the surface of the head, causing its temperature to increase by a fraction of a degree.
- Prolonged thermal effect may lead to increase in body temperature.

Non-Thermal Effects:-

- Non-thermal effects are attributed to the induced electromagnetic effects inside the biological cells of the body which is possibly more harmful².

2. Health effects are the changes which may be short term or long term. These effects stress the system and may be harmful to human health.

Mobile Service and EMF Radiation

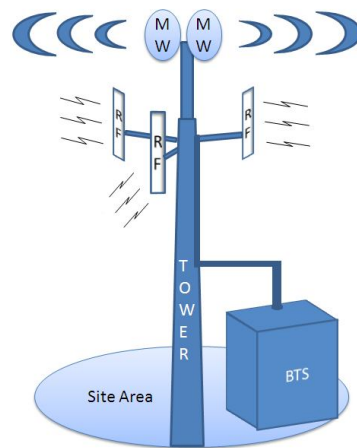
1.8 The EMF radiation in mobile services is primarily from two sources: - radiations from BTS and radiation from mobile handsets – both of which are at the relatively low end of electromagnetic spectrum. The energy carried by them is unable to break chemical bonds in molecules. Thus, they fall under the non-ionizing radiation category.

² R.F. Pollution Reduction in Cellular Communication; Sumit Katiyar , Prof. R. K. Jain, Prof. N. K. Agrawal

Radiation from mobile BTS

1.9 For providing mobile services, telecom service providers establish base transceiver stations (BTSs), at suitable locations, as per their Radio Frequency (RF) Network Planning for proper coverage of the area and for meeting capacity requirements. Every antenna on a cell phone tower radiates electro-magnetic power. A typical BTS³ site diagram is shown below in figure 1.3.

Figure1.3: Typical BTS site



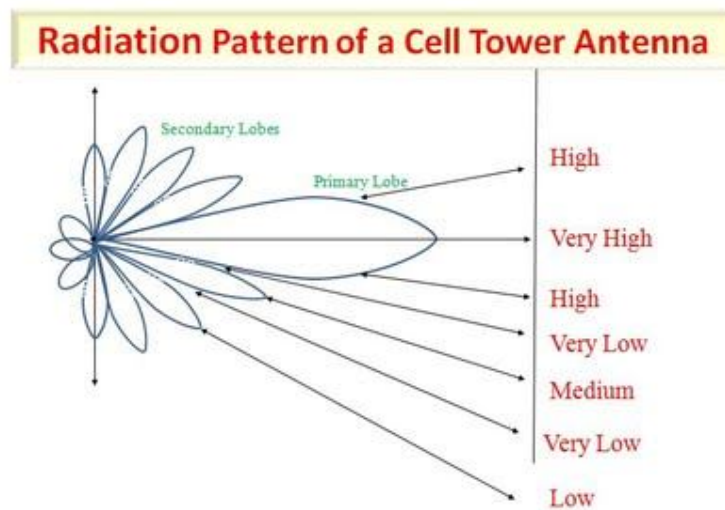
1.10 BTS also contain a number of radio transmitters and each of these has the same maximum output power. The outputs from the individual transmitters are then combined and fed via cables to the base station antenna, which is mounted at the top of a mast (or other suitable structure). Thus the radiated power would ideally be equal to the sum of the output power from the transmitters except for a small loss that occurs in the combiner and connecting cables. It should be noted that all the transmitters are not operational continuously; this depends on the call

³ A base transceiver station (BTS) is an equipment that facilitates wireless communication between user equipment and a network. It has the equipment for encrypting and decrypting communications, spectrum filtering tools etc. Antennas may also be considered as components of BTS to facilitate the functioning of BTS. Typically a BTS will have several transceivers which allow it to serve several different frequencies and different sectors of the cell.

traffic in each of the sectors. However the level of exposure is maximum at the time of peak traffic when all the channels are utilized and hence sectors with higher call traffic carry the risk of having maximum EM exposure.

- 1.11 The transmission power levels and the gain⁴ of the antennas used for transmission are other major factors to be considered when dealing with exposure levels. Typical gains for the sector antennas used with macro-cellular base stations in India are in the range 15–17 dBi for GSM900 systems and 16–18 dBi for GSM1800 systems. Omni directional antennas for macrocellular base stations are much less common than sector antennas, but generally have gains in the range 8–10 dB. However there are antennas with higher gain levels of 21 dB available recently in the market. Although the high gain antennas increase the efficiency and coverage, the risk of exposure for buildings in the close proximity of line of sight of the main beam of the antennas increases multifold.

Figure 1.4: Radiation from mobile BTS

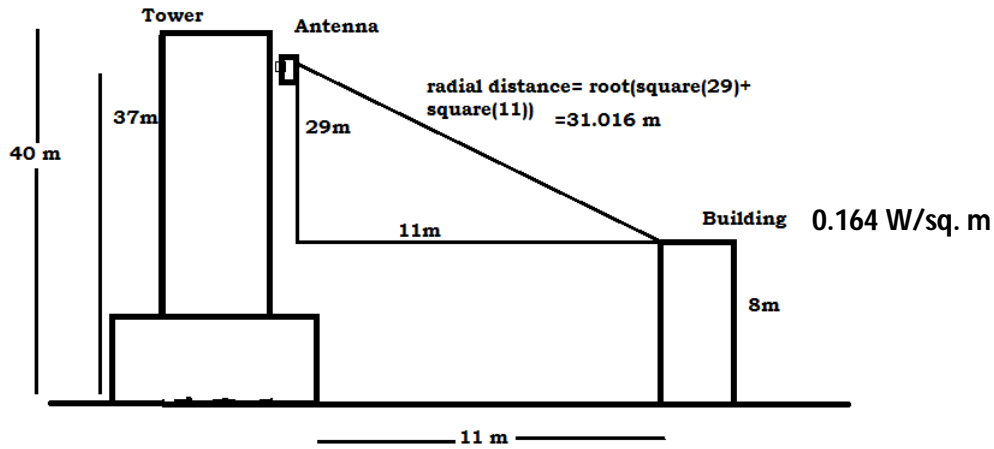


⁴ Antenna gain (expressed in decibels) is defined as the ratio of the power produced by the antenna from a source on the antenna's beam axis to the power produced by a hypothetical lossless isotropic antenna. As a transmitting antenna, this describes how well the antenna converts input power into radio waves headed in a specified direction. As a receiving antenna, this describes how well the antenna converts radio waves arriving from a specified direction into electrical power.

- 1.12 The real source of EM radiation is the transmitting antenna – not the transmitter itself, because the transmitting antenna is the main source that determines electromagnetic field distribution in the vicinity of a transmitting station. Radiation will be highest from the primary lobes in the horizontal direction. There is also radiation from secondary lobes which ranges from medium to very low when transmitting horizontally as seen in the figure 1.4 above. Hence, the direct exposure to the primary lobes along the line of antenna is the most severe of the exposed radiation. The radiation levels relatively taper as one moves away from the line of the antenna to its side lobes.
- 1.13 The distance from the source of radiation is another critical factor. The power density varies by $(1/R^2)$, where R is the distance. As one moves away from the antenna, the less is the radiation. In the figure 1.5 below, when a building of height 8 m is located at a horizontal distance of 11 m from a 40m Ground based tower (with an antenna at a height of 37 m), the region is in the safe zone. The calculated EMF power density⁵ is 0.164 Watts/sq.m and the building (assuming that the effect of radiation is only from the main lobes) is within the limits of the norms prescribed.(For 900MHz GSM, the limits prescribed is 0.45 Watts/sq.m)

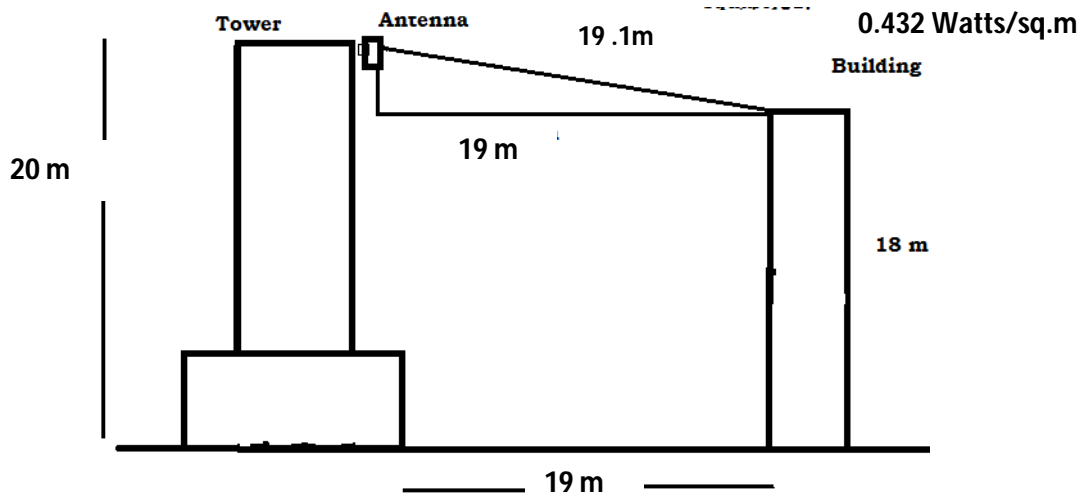
⁵ Calculations for a 4/4/4 GSM system transmitting 20 watts at 900 Mhz; radiations assumed from 2 sectors of the main lobes (worst case EMF scenario); antenna gain is 17dBi;combiner loss is 3dB; waveguide loss is 2.4dB; Automatic Transmit Power Control & Discontinuous transmission factor is .9;

Figure 1.5: EMF power density levels from mobile BTS



Even when a building of height 18 m, located at a horizontal distance of 19 m from a 10m tower (with an antenna at a height of 8 m) installed in the roof of a building, 10m high, the region is still in the safe zone. The calculated EMF power density⁶ is 0.432 Watts/sq.m and the building (assuming that the effect of radiation is only from the main lobes) is within the limits of the norms prescribed as shown in figure 1.6.

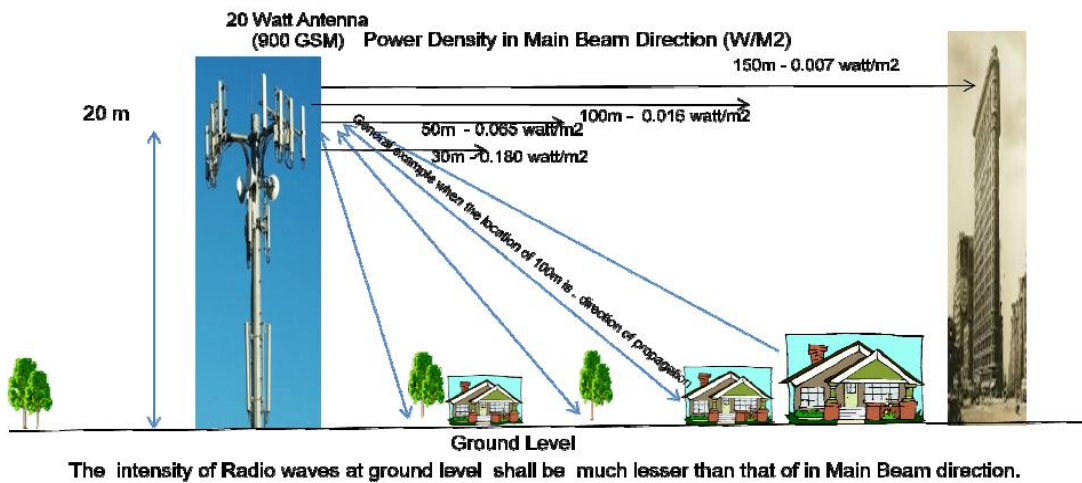
Figure 1.6: EMF power density levels from mobile BTS



⁶ Calculations for a 4/4/4 GSM system transmitting 20 watts at 900 MHz; radiations assumed from 2 sectors of the main lobes (worst case EMF scenario say the azimuth of the building with respect to the tower is 110degree); antenna gain is 17dBi;combiner loss is 3dB; waveguide loss is 2.4dB; Automatic Transmit Power Control & Discontinuous transmission factor is .9;

1.14 Generally, a cell phone tower is shared by more than one operator to provide mobile services. The more the number of antennas, the greater is the power intensity in the nearby area. Power levels near towers are higher and reduce with distance. It is reduced to $\frac{1}{4}$ when the distance from antenna doubles, and $\frac{1}{9}$ when distance is tripled and so on. The EMF power density varies with distance as shown in Figure 1.7 below.

Figure1.7 Power levels from the antenna



In addition, the safe distance from the tower also depends on the number of antennas served by the tower. The relation between antennas and distance is as given in the below table.

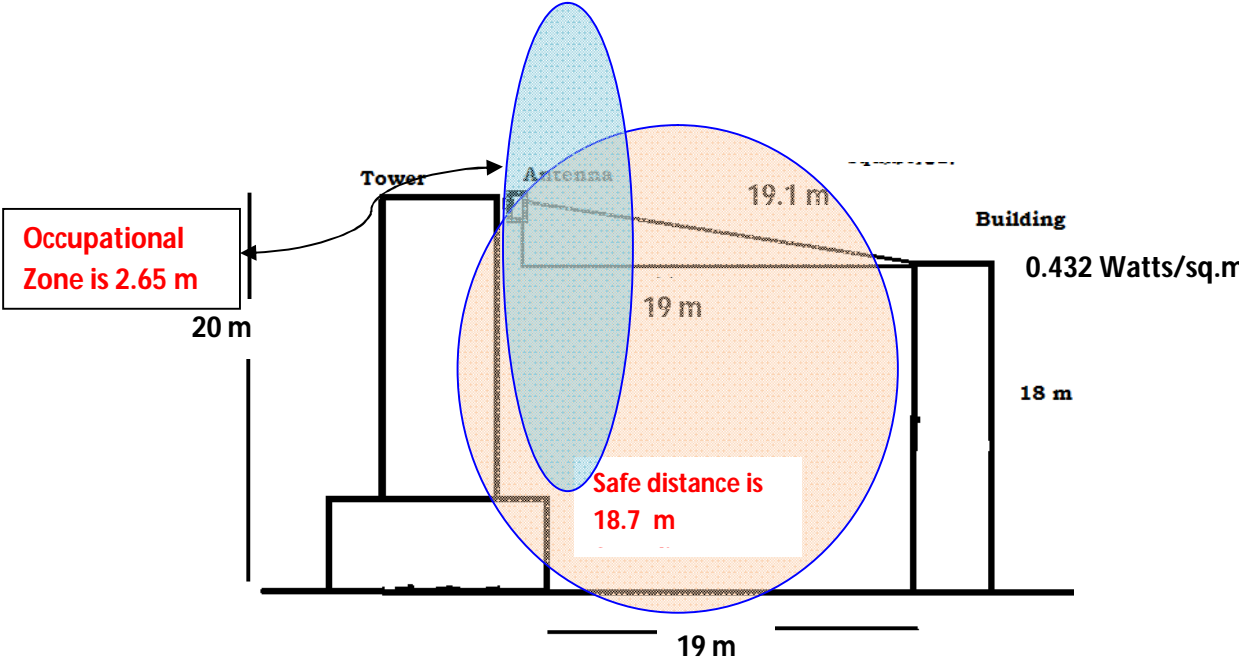
Table1.2: Safe distance in case of multiple antennas

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

1.15 In any particular exposure situation, the calculated values should be compared with the appropriate reference values (ICNIRP levels).

Compliance with the reference level will ensure compliance with the relevant quantities like current density, specific absorption rate and power density. If the measured value exceeds the reference level it is necessary to test compliance with the relevant field quantity and to determine whether additional protective measures are necessary.

Figure 1.8: Occupational & Compliance Zone



Based on the reference level specified by ICNIRP, the compliance distance from base station antenna could also be calculated with the help of Equivalent Iso-Tropically Radiated Power (EIRP in watts) in the direction of the maximum gain of the antenna. Hence, three types of exposure zones can be identified:

- (a) Compliance zone – where potential exposure to EMF is below the applicable limits. In the figure 1.8 above, the compliance zone is 15.74m.
- (b) Occupational zone-where potential exposure of EMF is below the limits for occupational exposure but exceeds the limits for general

public exposure. Here, 'occupational' refers to operational and maintenance staff. In the figure 1.8 above, this zone is 2.2m.

(c) Exceedance Zone - where potential exposure of EMF exceeds the limits for both occupational and general public exposure.

Figure 1.9: Exclusion Zone



For distances greater than the compliance zone, the radiation levels are under limits. Compliance zone indicates a safe distance from the antennae. In the compliance zone, potential exposure to EMF is below the applicable limits as shown in figure 1.9 above.

1.16 In addition, EMF radiation depends on the following:-

- Frequency / wavelength of RF signal being transmitted;
- Radio Frequency Power radiated from the antenna;
- Duration of Exposure of RF signal at a given distance from the antenna ;
- Exposure from other antennas located in the area;
- Duration/ frequency of recurrent exposure ;
- Temperature and humidity.

Radiation from Mobile Handsets:

1.17 Exposure to low-frequency electromagnetic fields normally results in negligible energy absorption and no measurable temperature rise in the body. However, exposure to electromagnetic fields at frequencies above

100 KHz can lead to absorption of energy and increase in body temperature. At frequencies between 100 kHz and 20 MHz, significant absorption may occur in the neck and legs; at frequencies in the range of 20 MHz to 300 MHz, relatively high absorption can occur in the whole body; when frequencies are in the range of around 300 MHz to several GHz, significant local, non-uniform absorption occurs; and in frequencies above 10 GHz, energy absorption occurs primarily at the body surface.

1.18 In mobile phones, frequencies ranging from 800 MHz to 2100 Mhz are normally used. However, the EMF radiation levels are within limits because the power radiated from the headset is low around 1 W and each headset operates within a prescribed Specific Absorption Rate (SAR) that reflects the amount of radio waves absorbed by the body tissue during use of a mobile phone. Between 100 kHz and 10 GHz these basic restrictions are provided on SAR to prevent whole body heat stress and excessive localized tissue heating. The limits for SAR, as determined by the strength of the electromagnetic field necessary to reach the body are accordingly set and they are an indicator for ensuring that equipment like mobile phones are operating within the prescribed parameters.

1.19 SAR is a measure of the rate at which energy is absorbed by the human body when exposed to EMF. It is defined as the power absorbed per mass of tissue and has units of watts per kilogram (W/kg). SAR is usually averaged either over the whole body, or over a small sample volume (typically 1 g or 10 g of tissue). The value cited is then the maximum level measured in the body part studied over the stated volume or mass.

1.20 SAR values for mobile phones always refer to the maximum possible transmission power. However, these values will only be reached under low field strengths in areas of low coverage. SAR values do not take into

consideration the specific transmission properties of each mobile phone. They indicate the possible maximum and not the actual or average transmission power.

1.21 Different mobile handsets create varying electromagnetic fields owing to differences in their design and construction, as well as their electronics and antenna. Therefore, even though SAR values are an important indicator to compare the maximum possible EMF exposure, a single SAR value does not provide sufficient information about the amount of EMF exposure under practical usage conditions to reliably compare individual cell phone models.

ICNIRP Guidelines for EMF Radiation

1.22 International Commission on Non-Ionizing Radiation Protection (ICNIRP) is a body of independent scientific experts covering areas of Epidemiology, Biology, Dosimetry and Optical Radiation and a number of consulting experts. This body studies possible adverse effects on human health from exposure to non-ionising radiation. ICNIRP's principal aim is to disseminate information and advice on the potential health hazards of exposure to non-ionizing radiation. As per the ICNIRP Guidelines, the levels of safety are:

Frequency Range	Power Density (Watt/Sq. Meter)
400MHz to 2000MHz (2GHz)	$f/200$
2GHz to 300GHz	10

(f : is the frequency of operation in MHz)

EMF Radiation Norms in India for mobile towers (BTS):

1.23 In India, monitoring of the radiation emanating from the BTS is carried out by the Department of Telecommunications (DoT). The DoT has issued instructions regarding setting up of acceptable EMF radiation limits and the testing procedure to be followed. The Telecom Enforcement Resource & Monitoring (TERM) Cells, a unit of DOT, tests upto 10% of BTS sites selected randomly by them. Additionally, BTS sites, against which there are public complaints, are also tested by TERM Cells. In 2008, DoT has adopted the ICNIRP Guidelines and prescribed limits/levels for antennas (Base Station Emissions) for general public exposure. Accordingly, the License conditions of telecom service providers were also amended by DoT in November 2008 by inserting a clause 43.6A in the Unified Access Services (UAS) license agreement. Clause 43.6A reads as under:-.

"43.6 A. Licensee shall conduct audit and provide self-certificates annually as per procedure prescribed by Telecommunication Engineering Centre (TEC)/or any other agency authorized by licensor from time to time conforming to limits/levels for antennae (Base station Emissions) for general public exposure as prescribed by International Commission on Non-Ionizing Radiation Protection (ICNIRP) from time to time. The present limits/levels are reproduced as detailed below:

Frequency Range	E-Field Strength (Volt/Meter (V/m))	H-Field Strength (Amp/Meter (A/m))	Power Density (watt/Sq. Meter (W/Sq. m))
400MHz to 2000MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$f/200$
2GHz to 300GHz	61	0.15	10

(f=frequency in MHz)

Note: The compliance in the form of Self Certificate shall commence six months after the date of issue of prescribed test procedure by TEC or any other agency authorized by licensor."

- 1.24 As per instructions issued by DoT, vide their letter No. 800-15/2010-VAS dated 08.04.2010 implementation of radiation within norms of EMF exposure of BTS is entrusted to TERM Cell of DoT. All the telecom service providers were also directed to submit to the respective TERM Cells self-certificates to the effect that they had met the radiation norms.
- 1.25 On 24.08.2010, the DoT set up an Inter-ministerial Committee (IMC) consisting of officers from DoT, Indian Council of Medical Research (Ministry of Health), Department of Biotechnology and Ministry of Environment and Forest to examine the effects of Electro Magnetic Field radiation from base stations and mobile phones.
- 1.26 The IMC has given its recommendations on various issues related to EMF radiation by mobile tower and handsets. The report states that:
- "Member Scientist, ICMR has indicated that the hot tropical climate of the country, low body mass index (BMI), low fat content of an average Indian as compared to European countries and high environmental concentration of radio frequency radiation may place Indians under risk of radio frequency radiation adverse effect."*
- So there is a need to explore the possibility of impact of geographical location on adverse health effect from EMF radiation from mobile towers.
- 1.27 The report also specifies monitoring of the EMF radiation. It also proposed that the provision of EMF radiation monitoring network may be considered similar to that of the national ambient air monitoring network or ambient noise monitoring network or weather monitoring stations. It also recommended provision of online monitoring of radiation levels through establishment of static testing and measuring centers at major

cities. The collected data could then be sent to central servers for further processing. This is similar to the measurement of pollution levels (noise and air quality) by the Central Pollution Control Board, under the Ministry of Environment and Forests.

- 1.28 The report also recommends that the SAR value information is to be embossed and displayed on the handset. The SAR value information of different mobile handsets should be made available on the Government's website and to the concerned regulatory agency. The report also recommends long-term scientific research related to health aspects of EMF radiation exposure and associated technologies.

- 1.29 The IMC has examined 90 international and national studies/reference papers related to EMF radiation before finalizing the report. In its report, IMC has indicated that most laboratory studies were unable to find a direct link between exposure to radio frequency radiation and health; and the scientific studies as yet have not been able to confirm a cause and effect relationship between radio frequency radiation and health. The effect of emission from cell phone towers is not known yet with certainty. Nevertheless, the IMC recommended lowering the mobile towers' EMF exposure limits to 1/10th of the existing prescribed limit as a matter of abundant precaution. Subsequently, the Department of Telecommunications has accepted the recommendations of the IMC and amended the Clause 43.6 A of Unified Access Services License on 10.01.2013, to include the revised limits/levels:

“43.6 A. The present limits/levels are reproduced as detailed below:

Frequency Range	E-Field Strength (Volt/Meter (V/m))	H-Field Strength (Amp/Meter (A/m))	Power Density (W/Sq. m)
400MHz to 2000MHz	$0.434f^{1/2}$	$0.0011f^{1/2}$	$f/2000$
2GHz to 300GHz	19.29	0.05	1

(f=frequency in MHz)”

1.30 Consequent to this revision by DoT, **Indian standards are now 10 times more stringent than many countries (like USA, Canada, Japan and Australia) in the world which follow ICNIRP guidelines.** A number of countries have specified their own radiation levels keeping in view the environmental and physiological factors. The power density limits vary from 0.001 Watt/ m² to 12 Watt/ m² at 1800 MHz operating frequency as shown in Table 1.4 below. In India the prescribed reference level at 1800 MHz is 0.92 Watt/ m² and at 900 MHz is 0.45 Watt/m² as shown in Table 1.3 below.

Table1.3: Revised EMF radiation norms for mobile towers (BTS) in India

Frequency	ICNIRP Radiation norms	Revised DoT Norms effective from 01.09.2012
900 MHz	4.5 Watt/ sq.m	0.45 Watt/sq.m
1800 MHz	9 Watt/ sq.m	0.9 Watt/sq.m
2100 MHz	10.5 Watt/ sq.m	1.05 Watt/sq.m

Table1.4: International EMF radiation norms for mobile towers (BTS)

International Exposure limits for EMF (1800 MHz)	
12 W/m ²	USA, Canada and Japan
9.2 W/m ²	ICNIRP and EU recommendation 1998
9 W/m ²	Exposure limit in Australia
2.4 W/m ²	Exposure limit in Belgium
1.0 W/m ²	Exposure limit in Italy, Israel
0.5 W/m ²	Exposure limit in Auckland, New Zealand
0.45 W/m ²	Exposure limit in Luxembourg
0.4 W/m ²	Exposure limit in China
0.2 W/m ²	Exposure limit in Russia, Bulgaria
0.1 W/m ²	Exposure limit in Poland, Paris, Hungary
0.1 W/m ²	Exposure limit in Italy in sensitive areas
0.095 W/m ²	Exposure limit in Switzerland
0.09 W/m ²	ECOLOG 1998 (Germany) Precaution recommendation only
0.001 W/m ²	Exposure limit in Austria

EMF Radiation limit from Mobile Handsets:

1.31 With effect from 1st Sept. 2012, the SAR values for mobile phones have been revised to 1.6 W/kg averaged over 1 gram of human tissue.

Table1.5: Revised EMF radiation norms for mobile handset

Frequency (10 MHz to 10 GHz)	ICNIRP SAR Limit	Revised SAR Limit effective from 01.09.2012
General Public Exposure	2 Watt/Kg (averaged over 10gm tissue)	1.6 watt/Kg (averaged over 1 gm tissue)

Table1.6: SAR values for mobile handsets of some countries

Countries	SAR value limits
China	2W/kg averaged over 10g of tissue
Singapore	2W/kg averaged over 10g of tissue
Ghana	2W/kg averaged over 10g of tissue
Brazil	2W/kg averaged over 10g of tissue
Nigeria	2W/kg averaged over 10g of tissue
Japan	2W/kg averaged over 10g of tissue
Rep. of Korea	2W/kg averaged over 10g of tissue
Europe	2W/kg averaged over 10g of tissue
Australia	1.6 W/kg averaged over 1 g of tissue
USA	1.6 W/kg averaged over 1 g of tissue
Canada	1.6 W/kg averaged over 1 g of tissue

India has adopted the most stringent SAR values for mobile handsets when compared to other countries (at par with USA, Canada & Australia).

1.32 From 1st Sept. 2013, only mobile handsets with the revised SAR value of 1.6 W/kg are permitted to be manufactured or imported into India. It is mandatory for manufacturers to display the SAR level on each mobile handset.

Chapter-II: Studies on the effects of EMF

- 2.1. In the recent past, people living in vicinity of cell towers have raised the issue of adverse health effects of radiation emanating from cell towers. Some studies have been conducted in this regard in various countries. A group of experts believe that the EMF radiation emitted from BTS and mobile handsets causes health hazards to human beings, animals, birds etc. Some experts describe the short term health disorders caused by this kind of radiation as “microwave sickness” or “radiofrequency syndrome” which includes headache, fatigue, irritability, sleeping disorders etc.
- 2.2. The biological effects of radio waves are being explored. Various studies have been conducted in different countries; however, there is no conclusive evidence of adverse effect of EMF radiation on human health. In order to assess the scientific evidence of possible health effects of EMR in the frequency range from 0 to 300 GHz, the World Health Organization (WHO) established the International EMF Project in 1996. WHO released a fact sheet on “Electromagnetic fields radiation and public health: Base stations and wireless technologies” in May 2006 wherein it has held that:
- “Considering the very low exposure levels and research results collected, there is no convincing scientific evidence that the weak RF signals from cell phone towers and wireless networks cause adverse health effects” and in its fact sheet on “Electromagnetic fields radiation and public health: mobile phones in June 2011 held that “..to date, no adverse health effects have been established as being caused by mobile phone use”.*

2.3. In its latest update in September 2013, WHO had stated that:

“While an increased risk of brain tumors from the use of mobile phones is not established, the increasing use of mobile phones and the lack of data for mobile phone use over time periods longer than 15 years warrant further research of mobile phone use and brain cancer risk. In particular, with the recent popularity of mobile phone use among younger people, and therefore a potentially longer lifetime of exposure, WHO has promoted further research on this group and is currently assessing the health impact of RF fields on all studied endpoints.”

2.4. Some of the statements from other international organisations include:

- **Health Protection Agency (HPA), UK (April 2012)-**

“No convincing evidence that RF field exposures below guideline levels of ICNIRP cause health effects in adults or children.”

- **Swedish Radiation Safety Authority (SRSA) (2010)-**

“...for up to about ten years of mobile phone use associations with brain tumour risk are unlikely. ...For longer duration of use, for specific subtypes of cancer, and for children and adolescents data are sparse or non-existing, and conclusions are less certain.”

- **UK Independent Advisory Group on Non-Ionizing Radiation (AGNIR) (2012)-**

“In summary, although a substantial amount of research has been conducted in this area, there is no convincing evidence that RF field exposure below guideline levels causes health effects in adults or children”

- **Danish Cohort Study, 2011-**

“There is no evidence of any increased risk of brain or nervous system tumours or any cancer mobile phone subscribers”

- **Norwegian Institute of Public Health (NIPH), 2012-**

“The large total number of studies provides no evidence that exposure to weak RF fields causes adverse health effects.”

2.5. In India, Department of Science & Technology (DST) constituted a committee on 01.10.2012, under the Chairmanship of Former Director General (ICMR), having representatives from Indian Institute of Technology (IIT) Chennai, Indian Institute of Toxicology Research, Lucknow, ICMR, Ministry of Health, Department of Telecom, Ministry of Environment & Forests and Dept. of Science & Technology. Request for Proposals (RFPs) on scientific assessment of possible health hazards and adverse impact on ecology in India specific context from Mobile Hand Sets & Mobile towers was also floated. The scope for this proposal will consider various factors that affect radiation levels, viz: High Population Density, in-organic Urban Growth, Narrow Lanes, Low Body Mass Index, Low Fat Content, and no. of Operators (10-12 in each Licensed Area).

STUDIES SUPPORTING OR DISCREDITING THE CONJECTURE OF ILL EFFECTS OF EMF RADIATION ON BIOLOGICAL LIFE FORMS

Radiation Energy

2.6. There have been arguments that EMF radiation has the potential to mutate DNA and cause cancer. However, to mutate a DNA, we need a certain threshold energy (energy per photon). It takes about 12eV to ionize water (hydrogen-oxygen covalent bond). EM radiation with photonic energy of more than 10 eV is generally considered ionizing.

Visible light photons have about 2eV of energy while EM radiation photons at 300 GHz have only 1.24 meV (approx.) of energy. Hence, clearly EM radiation originating from cellular operations does not have enough energy to break chemical bonds or cause ionization. Hence diseases like cancer cannot be attributed to EM radiation from communication infrastructure⁷.

Electromagnetic Hypersensitivity (EHS)

- 2.7. One potentially harmful effect of radio-frequency radiation is dielectric heating due to absorption of EM radiation⁸. However, if the temperature increase is small, the brain blood circulation is capable of disposing the excess heat by increasing the local blood flow. This is the normal cellular response to increase in temperature and does not have any adverse effect on the body.
- 2.8. Some also argue that there are other various symptoms like fatigue, sleep disturbance, loss of memory, disturbance indigestion etc. which have been attributed to exposure to low-level EM radiation from wireless devices. These symptoms are collectively known as Electromagnetic Hypersensitivity (EHS).
- 2.9. However, a study conducted by the WHO⁹ concluded that EHS is characterized by a variety of non-specific symptoms that differ from individual to individual. The symptoms are certainly real and can vary widely in their severity. Whatever its cause, EHS can be a disabling problem for the affected individual. However, EHS has no clear

⁷ "The Myth of Cell Phone radiation", VasantNatrajan, arXiv PHYSICS, <http://arxiv.org/abs/1211.5203> ($E = h\nu$ is the equation that governs the energy of photons in the EM radiation of frequency ν where h is the Plank's constant.)

⁸ Report of the Inter-Ministerial Committee on EM radiation, Government of India, DoT, 2011
⁹ <http://www.cancer.gov/cancertopics/factsheet/Risk/cellphones>; <http://www.who.int/mediacentre/factsheets/fs193/en/>

diagnostic criteria and there is no scientific basis to link EHS symptoms to EM radiation. Furthermore, EHS is not a medical diagnosis, nor is it clear that it represents a single medical problem.

2.10. A number of studies have continued to report some link between exposure to EMF radiation and occurrence of a variety of health disorders, though these studies are considered inconclusive. For instance, the US National Cancer Institute has concluded that there is no danger of cancer from cell-phone radiation¹⁰.

Published results

2.11. In some experiments conducted on rats, it was suggested that EM radiation can affect the reproductive health of rats¹¹ (ICMR and CSIR funded study by JNU).

2.12. However, the results of these experiments were not published in any peer reviewed international journal. Therefore, the credibility of the report is not conclusively established. The claim regarding formation of free radicals during the course of long exposure of rats to EMF from cell phones is also not beyond doubt viz. not substantiated.

2.13. There are reports of harmful effects of EM radiation on birds, bees etc. Animals that depend on the natural electrical, magnetic and electromagnetic fields for their orientation and navigation through earth's atmosphere are confused by the much stronger and constantly changing artificial fields created by technology and fail to navigate back to their home environments. On this, the Agricultural Research Service, US

¹⁰ www.cancer.gov/cancertopics/factsheet/Risk/cellphones

¹¹ <http://www.thehindu.com/news/national/health-threat-to-mobile-users-jnu-study/article1033086.ece>];http://articles.timesofindia.indiatimes.com/2011-10-18/kochi/30296603_1_mobile-towers-cell-phone-tower-mobile-phones];http://www.hese-project.org/hese-uk/en/papers/warnke_bbm.pdf

Department of Agriculture has said that despite a great deal of attention, neither cell phones nor cell phone towers have any connection to Colony Collapse Disorder (CCD) or poor honey bee health. A study was conducted in Germany to find whether there is any connection between CCD and radiation effects¹². The study examined whether a particular type of base station for cordless phones could affect honey bee homing systems. However, causality was not conclusively established viz. the base station has nothing to do with CCD. Stefan Kimmel, the researcher who conducted the study and wrote the paper, e-mailed 'The Associated Press' to say that there is "*no link between our tiny little study and the CCD-phenomenon ... Anything else said or written is a lie.*" In addition, apiaries are often located in rural areas, where cell phone coverage can be spotty. This makes cell phones or cell towers unlikely to cause CCD behaviour in a substantial manner.

Cataract due to cell phones?

2.14. Any dielectric material (such as living tissue) could be heated by rotations of polar molecules induced by the electromagnetic field (Dielectric heating). For a person using a cell phone, most of the heating effect will occur at the surface of the head, causing its temperature to increase by a fraction of a degree. In this case, the level of temperature increase is less in magnitude than obtained during the exposure of the head to direct sunlight. The brain's blood circulation is capable of disposing of excess heat by increasing local blood flow. However, the cornea of the eye does not have this temperature regulation mechanism and any exposure of 2–3 hours duration have been reported to produce cataracts in rabbits' eyes at SAR values from 100-140W/kg, which can

¹² <http://www.ars.usda.gov/News/docs.htm?docid=15572#phones>

produce lenticular temperatures¹³ (variations of temperatures resulting in lens shaped effect in the eye) of 41°C. However, strangely there was no cataract detected in the eyes of monkeys which were also exposed under similar conditions.

- 2.15. It should be noted that the SAR value of 100-140W/kg used in the reported experiments are very high and thus premature cataract cannot be linked with cell phone use, possibly because of the lower power output of mobile phones. In India the SAR values for mobile phones is 1.6W/kg, (averaged over 1 gram). SAR is usually averaged either over the whole body, or over a small sample volume (typically 1 g or 10 g of tissue).
- 2.16. Another preliminary study¹⁴ published in 2011 by the Journal of the American Medical Association conducted using fluorodeoxyglucose injections and positron emission tomography concluded that exposure to radiofrequency signal waves within parts of the brain closest to the cell phone antenna resulted in increased levels of glucose metabolism, but the clinical significance of this finding is unknown.
- 2.17. Swedish researchers from Lund University¹⁵ (Salford, Brun, Persson, Eberhardt, and Malmgren) have studied the effects of microwave

¹³ International Commission on Non-Ionizing Radiation Protection (April 1998). "Guidelines For Limiting Exposure To Time-Varying Electric, Magnetic, And Electromagnetic Fields (up to 300 GHz)" (PDF). *Health Physics* 74 (4): 494–505.

¹⁴ Volkow, Nora D.; Tomasi, Dardo; Wang, Gene-Jack; Vaska, Paul; Fowler, Joanna S.; Telang, Frank; Alexoff, Dave; Logan, Jean et al. (2011). "Effects of Cell Phone Radiofrequency Signal Exposure on Brain Glucose Metabolism". *JAMA* 305 (8): 808–13.

¹⁵ Salford, Leif G.; Arne E. Brun, Jacob L. Eberhardt, Lars Malmgren, and Bertil R. R. Persson (June 2003). "Nerve Cell Damage in Mammalian Brain after Exposure to Microwaves from GSM Mobile Phones". *Environmental Health Perspectives* (United States: National Institute of Environmental Health Sciences) 111 (7): 881–883. Salford, Leif G.; Henrietta Nittby, Arne Brun, Gustav Grafstrom, Lars Malmgren, Marianne Sommarin, Jacob Eberhardt, BengtWidegren, Bertil R. R. Persson (2008). "The Mammalian Brain in the Electromagnetic Fields Designed by Man with Special Reference to Blood-Brain Barrier Function, Neuronal Damage and Possible

radiation on the rat brain. They found a leakage of albumin into the brain via a permeated blood–brain barrier. This confirms earlier work on the blood–brain barrier by Allan Frey, Oscar and Hawkins, and Albert and Kerns. Other groups doing similar studies¹⁶ have not confirmed these findings in vitro cell studies or whole animal studies. However Frey¹⁷ alleges that an editor determined that a researcher who claimed that his attempts to replicate Frey's research had not validated Frey's results, had incorrectly interpreted his own results, and that his research had confirmed Frey's results.

2.18. A 2009 study¹⁸ examined the effects of exposure to EMF radiation emitted by standard GSM cell phones on the cognitive functions of humans. The study confirmed longer (slower) response times to a spatial working memory task when exposed to EMF radiation from a standard GSM cellular phone, placed next to the head of male subjects, and showed that longer duration of exposure to EMF radiation may increase the effects on performance. Right-handed subjects exposed to EMF radiation on the left side of their head on an average had significantly longer response times when compared to exposure to the right side and

Physical Mechanisms". Progress of Theoretical Physics Supplement (Japan: Physical Society of Japan) 173: 283–309.

¹⁶ Franke et al. (1800). "do not alter blood–brain barrier permeability to sucrose in models in vitro with high barrier tightness". *Bioelectromagnetics* 26 (7): 529–535. Kuribayashi et al. "Lack of effects of 1439 MHz electromagnetic near field exposure on the blood–brain barrier in immature and young rats". *Bioelectromagnetics* 26 (7): 578–588.

¹⁷ Frey, Allan. "Headaches from Cellular Telephones: Are They Real and What Are the Implications?". *Environmental Health Perspectives*.

¹⁸ Luria, Roy; Eliyahu, Ilan; Hareuveny, Ronen; Margalioth, Menachem; Meiran, Nachshon (2009). "Cognitive effects of radiation emitted by cellular phones: The influence of exposure side and time". *Bioelectromagnetics* 30 (3): 198–204.]

sham-exposure. However, similar independent studies are required to be conducted in the form of double blind tests in order to verify the reports of the cited study. The EMF exposure is directly related to the usage of mobile handsets. However in India as on December 2013, the Minutes of Usage (MOU) per subscriber is only 379 minutes per month for GSM and 230 minutes per month for CDMA. This means the average time the cell phones are near the head is only 12.6 minutes in a day. Hence, the EMF radiation is considerably low.

Effects during Pregnancies

- 2.19. A study on mice offspring¹⁹ suggested that cell phone use during pregnancy may cause behavioural problems that resemble the effects of Attention Deficit Hyperactivity Disorder (ADHD).
- 2.20. From the same study, it is noted that further research in humans is required, to better understand the mechanisms behind these findings and to establish safe exposure limits during pregnancy. However, the first author of the study, Mr Tamir Aldad, added that rodent pregnancies last only 19 days and offspring are born with a less-developed brain than human babies, so further research is needed to determine if the potential risks of exposure to radiation during human pregnancy are similar.

Miscellaneous

- 2.21. Several surveys, as listed below, have found a variety of self-reported symptoms that include subjective symptoms, sleeping problems, and cognitive performance for people who live close to base stations.

¹⁹ Cell Phone Use in Pregnancy May Cause Behavioral Disorders in Offspring, Mouse Study Suggests". Science Daily.

<http://www.sciencedaily.com/releases/2012/03/120315110138.htm>

1. Santini, R; Santini, P; Danze, JM; LeRuz, P; Seigne, M (January 2003). "Survey Study of People Living in the Vicinity of Cellular Phone Base Stations". *Electromagnetic Biology and Medicine* (London: Informa Healthcare) 22 (1): 41–49.
2. Navarro, Enrique A; Segura, J; Portolés, M; Gómez-Perretta de Mateo, Claudio (December 2003). "The Microwave Syndrome: A Preliminary Study in Spain". *Electromagnetic Biology and Medicine* (London: Informa Healthcare) 22 (2): 161–169.
3. Oberfeld, Gerd; Navarro, Enrique A; Portoles, Manuel; Maestu, Ceferino; Gomez-Perretta, Claudio (2004). "The Microwave Syndrome: Further Aspects of a Spanish Study". In Kostarakis, P. *Biological effects of EMFs : Proceedings, Kos, Greece, 4–8 October 2004, 3rd International Workshop*. Ioannina, Greece: Electronics, Telecom & Applications Laboratory, Physics Dept., University of Ioannina : Institute of Informatics & Telecommunications, N.C.S.R. "Demokritos".
4. Abdel-Rassoul, G; Abou El-Fateh, O; Abou Salem, M; Michael, A; Farahat, F; El-Batanouny, M; Salem, E (March 2007). "Neurobehavioral effects among inhabitants around mobile phone base stations" (PDF). *NeuroToxicology* (New York, NY: Elsevier Science) 28 (2)
5. Bortkiewicz, A; Zmyślony, M; Szyjkowska, A; Gadzicka, E (2004). "Subjective symptoms reported by people living in the vicinity of cellular phone base stations: review". *Medycyna* (in Polish) (Warsaw: Państwowy Zakład Wydawnictw Lekarskich) 55 (4): 345–352.
6. Hutter, H-P; H Moshammer, P Wallner, M Kundi (May 1, 2006). "Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations". *Occupational and Environmental Medicine* (London, UK: the BMJ Publishing Group) 63 (5): 307–313.

2.22. But it is to be noted that there are significant challenges in conducting studies on people near base stations, especially in the assessment of individual exposure, as reported in similar studies.²⁰

Self-report studies can also be vulnerable to the Nocebo effect.

2.23. Two double-blind placebo-controlled trials conducted at the University of Essex and another in Switzerland concluded that mobile phone masts were unlikely to be causing these short term effects in a group of volunteers who complained of such symptoms.

²⁰ Neubauer et al. (2007). "Feasibility of future epidemiological studies on possible health effects of mobile phone base stations". *Bio electromagnetic* 28 (3): 224–230.

2.24. The Essex study²¹ found that subjects were unable to tell whether they were being exposed to electromagnetic fields or not, and that sensitive subjects reported lower well-being independently of the exposures. The principal investigator concluded:

"It is clear that sensitive individuals are suffering real symptoms and often have a poor quality of life. It is now important to determine what other factors could be causing these symptoms, so appropriate research studies and treatment strategies can be developed."

2.25. The Agence française de sécurité sanitaire environnementale²² currently says that there is no demonstrated short term effect of electromagnetic fields on health, but that there are open questions for long term effects, and that it's easy to reduce exposure via technological improvements.

2.26. A Variety of studies²³ over the past 50 years have been done on workers exposed to high EMF radiation levels subjects were radar laboratory workers, military radar workers, electrical workers, and amateur radio operators. Most of these studies found no increase in cancer rates over the general population or a control group. Many positive results could have been attributed to other work environment conditions, and many negative results (reduced cancer rates) have also occurred.

²¹ UMTS Base Station-Like Exposure, Well Being and Cognitive Performance Regel et al., Environmental Health Perspectives, 114(8) August 2006. Eltiti, S; Wallace, D; Ridgewell, A; Zougkou, K; Russo, R; Sepulveda, F; Mirshekar-Syahkal, D; Rasor, P; Deeble, R; Fox, E (November 2007). "Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? A double-blind randomized provocation study". Environ Health Perspect 115 (11): 1603–1608.

²² "Radiofréquences : actualisation de l'expertise (2009)", l'Agence Française de Sécurité Sanitaire Environnementale, April 2005

²³ Moulder, JE; Erdreich, LS; Malyapa, RS; Merritt, J; Pickard, WF; Vijayalaxmi (May 1999). "Cell phones and cancer: what is the evidence for a connection?". Radiation Research (New York: Academic Press) 151 (5): 513–531.

Summary

1. Because of the large number of users, there is now public concern about possible health hazards from EMF exposures from mobile phones or their base stations. Concerns have also been raised that continuous exposure to EMF radiation emanating from telecom towers causes harmful thermal and non-thermal health effects. The effects of exposure to radio frequency radiation have generated an active scientific debate among the research agencies across the globe.
2. It is pertinent to note that every day we are exposed to many sources of EMF radiation in our daily life viz., X-rays used in hospitals, wireless phones, computers, TV sets, microwave ovens, extension cables, electric cooking ranges, refrigerators, freezers, and other electrical home appliances. Some of the other sources of EMF radiation are power lines, cable and satellite communications, power stations, electric transportation vehicles (electric trains, trams and trolley buses), security scanners, TV and radio repeaters. The electromagnetic radiation from the mobile towers and handsets are non-ionizing and do not carry enough energy per quantum to ionize or break the atoms or molecules causing any harm to the human health.

3. The guidelines for EMF radiations from BTS and mobile handsets in India are very stringent when compared to developed countries. In case of EMF radiation from BTSs, the prescribed values are 1/10th the ICNIRP guidelines and they are better than the standards adopted by some developed countries like USA, Canada, Japan and Australia. Also for EMF radiation from handsets, the SAR values prescribed are no more or the same as that in developed countries like USA, Canada, Japan and Australia.

4. Various international organisations like WHO, HPA, SRSA, AGNIR, NIPH have stated, in no uncertain terms, that there is no convincing evidence linking EMF exposures with health effects in adults or children. Moreover, over the past few years, various academic studies have been published worldwide on the effects of EMF radiation emanating from mobile towers. Some of the studies report the absence of a risk to human beings from EMF radiations. Yet others report the presence of a risk; however, most of these are far from conclusive and come with the usual academic caveat about further studies. In short, there is no clear-cut scientific evidence available as of today which establishes causality between EMF radiation and disease in human beings in so far as it relates to EMF radiation from either towers or cell phones.

5. However, as pointed out by the IMC, India-specific studies taking into considerations the hot tropical climate of the country, low body mass index (BMI), low-fat content of an average Indian, need to be undertaken. In this regard DST is examining the prospects of a scientific assessment for possible health hazards and adverse impact on ecology in India specific context from Mobile Hand Sets & Mobile towers.

6. To sum up: EMF radiation is a fact of life. Most human beings are exposed to some form of EMF radiation on a daily basis. In the context of the telecom industry, such radiation emanates from towers and mobile phones. The crux of the matter is that whenever regulations and standards are to be set to limit any possible harm that such radiation could have on human beings, such regulations and standards must have a scientific basis. In the absence of being founded on science, the regulation/standard could be assailed as arbitrary. Moreover, it could end up limiting growth of industry merely based on a presumption. Surely, that could be a way forward for India. More studies have to be undertaken, especially so India specific studies. And, until those studies are completed and results validated, we need to be careful on how we approach EMF radiation.

Disclaimer:

The views expressed and data provided in the studies are of the respective authors and are not endorsed by TRAI. TRAI assumes no responsibility of the correctness or otherwise of these studies.

Acronyms

ADFT	Attention Deficit Hyperactivity Disorder
AM	Amplitude Modulation
BMI	Body Mass Index
BTS	Base Transceiver Station
CCD	Colony Collapse Disorder
CDMA	Code Division Multiple Access
CPE	Customer Premises Equipment
dB	Decibels
DNA	Deoxyribonucleic Acid
DoT	Department of Telecommunication
DST	Department of Science and Technology
EHS	Electromagnetic Hypersensitivity
ELF	Extremely Low Frequency
EM	Electro-Magnetic
EMF	Electric and Magnetic Fields
EMR	Electromagnetic radiation
FCC	Federal Communications Commission
FM	Frequency Modulation
GHz	Giga Hertz
GSM	Global System for Mobile
ICMR	Indian Council of Medical Research
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IMC	Inter-ministerial Committee
IMEI	International Mobile Equipment Identity
RF	Radio Frequency
RFP	Request for Proposals
RFR	Radio Frequency Radiation
SAR	Specific Absorption Rate
TEC	Telecommunication Engineering Center
TERM	Telecom Enforcement Resource and Monitoring
TRAI	Telecom Regulatory Authority of India
TV	Television
UAS	Unified Access Services
UHF	Ultra High Frequency
VHF	Very High Frequency
WHO	World Health Organization
WLAN	Wireless Local Area Network