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Hazardous Radiations from Mobile Phones and Cell Towers – A ReviewSAKSHI CHAUDHARY¹, PRAMOD KUMAR², SHASHANK CHAUDHARY³
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<http://dx.doi.org/10.22147/jusps-B/290801>**Acceptance Date 10th July, 2017, Online Publication Date 2nd August, 2017****Abstract**

Mobile technology has taken the telecommunication sector by storm. The technology itself has evolved and grown at an exponential pace. However, the health risks associated with it have also shown an upward trend. This paper starts with a basic introduction to the EMF radiation, how they are emitted through the cell towers and mobile phones. It then talks about the causes & sources of these health hazards, certain metrics like the safety distance & the statutory norms prevalent in different countries as contrast to India. The paper also reviews some of the already published results from different experiments and studies conducted in this domain across the world. Lastly, the paper draws some inference and conclude with basic precautions to reduce the adverse effects and recommendations to help reduce the levels of radiation in the environment.

Key words: Mobile Technology, Health Hazards, Electromagnetic Radiation, Ionizing Radiation, Non-Ionizing Radiation, Safe Power Density, EMF Radiation Norms.

Introduction

In this paper, we analyzed the effect of electromagnetic radiation from mobile phone and mobile tower. Mobile phone technology has revolutionized the telecommunication sector throughout the world. Due to its several advantages,

mobile phone technology has grown exponentially in the last three decades. Now in India, there are more than 93 crores connections, out of which 91 crores connections are wireless mobile phone and more than 5 lakhs mobile phone towers. All over the world, people have been debating about associated health risk due to electromagnetic radiation from mobile phone and mobile tower. Mobile phone and tower emit

electromagnetic radiation having health effects, which can be divided into thermal and non-thermal. Thermal effects are comparable to that of cooking in a microwave oven¹³, which you can observe if you hold the mobile phone for long near your ear. Non-thermal effects are 3 to 4 times more harmful than thermal effect. Electromagnetic radiation damages human cells, tissues, genes, and DNA. Mobile phones communicate by transmitting radio waves through a network of fixed antennas called base stations. Radiofrequency waves are electromagnetic fields. The paper also contains a write up on sources of exposure, absorption of energy from EM fields, effects of Electromagnetic exposure on humans, and International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for

Emissions from the tower.

Electro Magnetic Field Radiation :

Electromagnetic field (EMF) radiation is basically the flow of photons in space. Each photon has a particular amount of energy. Different types of radiations are defined on the basis of the amount of energy found in the respective photons. Electromagnetic radiation in our day life is used in microwave¹⁴ ovens and radars. Radio waves are used in radio and television broadcasts. Visible light is essential for normal vision. Infrared waves are mainly used in night vision goggles and in remote controls for TVs, Stereo, etc.

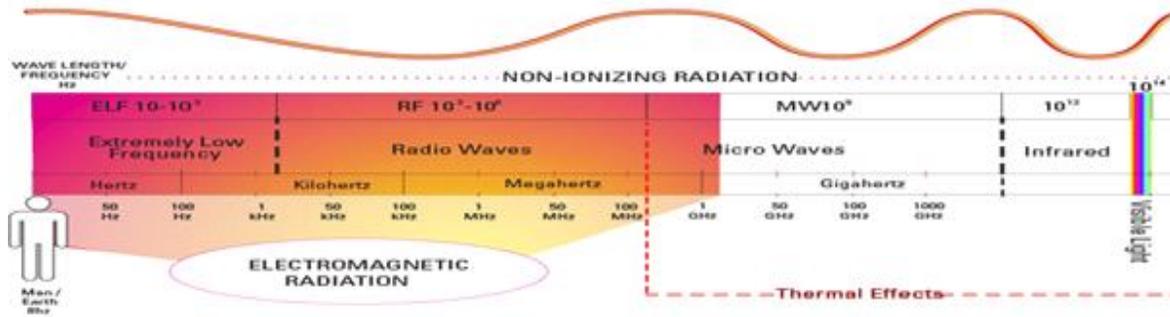


Figure 1 – Electromagnetic Spectrum

EMF radiations are two types, ionizing and non-ionizing. Ionizing radiation is the electromagnetic radiation which can create ions. These radiations have waves with energy sufficient to overcome the electron’s binding energy in atoms or molecules. e.g. X-rays, Ultraviolet rays, gamma rays, and cosmic rays. The radiation that does not carry enough energy per quantum required for ionizing the atoms or molecules

is called non-ionizing radiation. e.g. low-frequency radiations like infrared radiation, microwaves, and radio waves. EM emissions in the frequency range of 1 Hz to 1000 GHz are termed as non-ionizing²⁹.

The EMF radiation in mobile services comes primarily from two sources of radiations – first from the signal towers and second from the mobile phones, both of which are at the relatively lower end of the

Table 1 – EMF Source and operating frequency

S.No.	EMF Source	Operating Frequency	Transmission	Number
1	AM/FM Tower	540 KHz -108 MHz	1 KW – 30 KW	380
2	TV Tower	48 MHz – 814 MHz	10KW–500 W	1201
3	Wi-Fi	2.4GHz – 2.5 GHz	10 mW–100 mW	
4	Cell Towers	800,900,1800,2100,2300 MHz	20 W	~ 5 lakh
5	Mobile Phones	GSM-1800/CDMA, GSM-900	1W, 2W	910+ Million

electromagnetic spectrum. They don't carry enough energy carried to break chemical bonds in molecules. Thus, they fall under the non-ionizing radiation category.

*Radiation from mobile tower providing mobile services*²⁷

Telecom service providers establish base transceiver stations for proper coverage of the area and meeting capacity requirements. These base transceiver stations are placed at suitable locations in accordance to their Radio Frequency Network Planning. The antennas placed on these stations/cell phone towers radiate electromagnetic power.

The mobile tower contains a number of radio transmitters, each of which has the same maximum output power. Their outputs are then combined and fed to the base station antenna via cables. This antenna is mounted at the top of a mast. Thus the radiated power should ideally be equal to the sum of the output power from the radio transmitters except for a small loss that occurs in the combiner and connecting cables. Other major factors considered when dealing with exposure levels include the transmission power levels and the gain of the antennas used for transmission. Typical gains for sector antennas used with the macro mobile tower in India are in the range 15–17 dB for GSM900 systems and 16–18 dB for GSM1800 systems. Radiation from tower antenna gain is defined as the ratio of the power produced by the antenna from the source on the antenna's beam axis to the power produced by the hypothetical lossless isotropic antenna. For a transmitting antenna, this describes how well the antenna converts input power into radio waves headed in a specified direction. For a receiving antenna, this describes how well the antenna converts radio waves arriving from a specified direction into electrical power. The radiation levels relatively taper as one move away from the line of the antenna to its side lobes. The power density varies by the inverse of (R^2), where R is the distance. As one moves away from the antenna, the less is the radiation. When a building of height 8m is located at a horizontal distance of 11m from a 40m Ground-based tower with an antenna at the height of 37m, the region is in the safe zone. The calculated EMF power density is 0.164 Watts/sq.m.

Generally, a mobile tower is shared by multiple operators to provide mobile services. The power intensity in the nearby area increases with the increase in the number of antennas. Power levels near the towers are higher and reduce with the distance. It is reduced to 1/4 when the distance from antenna doubles, and 1/9 when the distance is tripled and so on.

The safe distance for Structure/ Building from the tower also depends on the number of antennas served by the tower. The relationship between antennas and distance is as given in the below table³.

Table 2. Safe distance in case of multiple antennas

S.No.	Number of Multiple antennas	Safe distance from the antenna (in meters)
1	2	35
2	4	45
3	6	55

The EMF radiation depends on the Radio Frequency Power radiated from the antenna, frequency of RF signal being transmitted, duration of exposure of RF signal from the antenna at a given distance, exposure from other antennas in the area, duration/frequency of recurrent exposure, temperature, and humidity.

Exposure to low-frequency electromagnetic fields at frequencies above 100 KHz can lead to absorption of energy and increase in body temperature. Significant absorption may occur in neck and legs in the frequencies range between 100 kHz and 20 MHz. Relatively high absorption can be seen in the whole body at frequencies in the range of 20 MHz to 300 MHz. Significant local and non-uniform absorption can occur when the frequencies are around 300 MHz to several GHz. Energy absorption at the body surface primarily occurs in the frequencies above 10 GHz

ICNIRP Guidelines for EMF Radiation :

ICNIRP - International Commission on Non-Ionizing Radiation Protection is a body of independent scientific experts covering the areas of Epidemiology, Biology and Optical Radiation and a number of

consulting experts. ICNIRP studies possible adverse effects of exposure to non-ionising radiation on human health. The principal aim of ICNIRP is to disseminate information & advice on the potential/probable health

hazards of exposure to non-ionizing radiation. According to ICNIRP¹ Guidelines, the levels of power density safety norms are given in the table 3.

Table 3. Safer Power density ICNIRP guidelines²

Frequency Range	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density Watt/Sq.m
400MHz - 2000MHz	$1.375 f^{\frac{1}{2}}$	$0.0037 f^{\frac{1}{2}}$	$\frac{f}{200}$
2GHz - 300GHz	61	0.15	10

In India 2008, DOT has adopted the ICNIRP Guidelines and prescribed limits for general public exposure which are revised by ICNIRP from time to time. On 24.08.2010, the DOT set up an Inter-ministerial Committee from DOT, ICMR, Department of Biotechnology and Ministry of Environment and forest^{5,6}. The IMC has given its recommendations on the various issues related to EMF radiation. The report states that: "Member Scientist, ICMR has indicated that the low body mass index (BMI), hot tropical climate of the country, low-fat content of an average Indian as compared to European countries along with high environmental concentration of radio frequency

radiation may place Indians under risk of radio frequency radiation adverse effect." The report also talks about the monitoring of the EMF radiation. It also recommended provision of online monitoring of radiation levels through the establishment of static testing and measuring center at major cities.

The IMC has examined 90 national and international studies/reference papers related to EMF radiation before finalizing the report. IMC recommendations included lowering the mobile towers EMF exposure limits to 1/10th of the existing prescribed limit as a matter of a Subsequently; the DOT has accepted the recommendations of the IMC

Table 4. Power Density adopted in India

Frequency Range	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density Watt/Sq.m
400MHz - 2000MHz	$0.434 f^{\frac{1}{2}}$	$0.0011 f^{\frac{1}{2}}$	$\frac{f}{200}$
2GHz - 300GHz	19.29	0.05	1

*EMF Radiation Norms in India for mobile tower*⁸

Indian standards at present are 10 times more stringent than many countries in the world which

follow ICNIRP guidelines. Different countries have specified their own radiation levels keeping in view the environmental and physiological factors.

Table 5. Revised EMF radiation norms for mobile towers in India

Frequency	ICNIRP Radiation Norms ⁷	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

Table 6. International EMF radiation norms for mobile towers

Power Density	Country	Power Density	Country
0.1 Watt/Sq.m	Poland, Paris, Hungary	0.1 Watt/Sq.m	Italy in sensitive areas
12 Watt/Sq.m	USA, Canada, Japan	0.5 Watt/Sq.m	Auckland, NewZealand
9 Watt/Sq.m	Australia	0.2 Watt/Sq.m	Russia, Bulgaria
2.4 Watt/Sq.m	Belgium	0.4 Watt/Sq.m	China
0.45 Watt/Sq.m	Luxembourg	0.001 Watt/Sq.m	Austria
0.95 Watt/Sq.m	Switzerland	0.1 Watt/Sq.m	Italy, Israel

*EMF Radiation limit from Mobile Phone*²³⁻²⁴

SAR is a measure of the rate at which energy is absorbed by the human body when exposed to radiation which is emitted from a mobile phone. It is also defined as the power absorbed per mass of tissue and is measured in watts per kilogram (W/kg). SAR is usually averaged over the whole body or over a small sample volume (1 gm or 10 gm of tissue). This value is the maximum level measured in the body part studied

over the stated volume or mass. General Public Exposure India has adopted the most stringent SAR values for mobile handsets. From 1st Sept. 2013, mobile handsets with the revised SAR value of 1.6 W/kg only are permitted to be manufactured or imported into India. It is mandatory for manufacturers to display the SAR level on each mobile handset.

In the table, the SAR limit for safer value in different country shown.¹⁹

Table 7. SAR values for mobile handsets in different countries

Country	SAR Limit (averaged over 10gm/1gm tissue)	Country	SAR Limit (averaged over 10gm/1gm tissue)
China	2 Watt/Kg (10gm tissue)	Ghana	2 Watt/Kg (10gm tissue)
Singapore	2 Watt/Kg (10gm tissue)	Brazil	2 Watt/Kg (10gm tissue)
Nigeria	2 Watt/Kg (10gm tissue)	Japan	2 Watt/Kg (10gm tissue)
Australia	1.6 Watt/Kg (1gm tissue)	Canada	1.6 Watt/Kg (1gm tissue)
Korea	2 Watt/Kg (10gm tissue)	Europe	2 Watt/Kg (10gm tissue)
India	1.6 Watt/Kg (1gm tissue)		

Studies on the effects of EMF :

In the recent past, people living in the vicinity of mobile towers have raised the issue of adverse health effects of radiation emitting from mobile towers. Some studies have been conducted in this regard in various countries. A group of experts believes that the radiation emitted from the tower and mobile phones causes health hazards to human beings, birds, animals, etc. Some experts describe the short-term health disorders caused by this kind of radiation as radio frequency syndrome or microwave sickness⁴, which includes irritability, fatigue, headache¹⁷, sleeping disorders¹⁸, etc.

The biological effects of radio waves are

being explored. Various studies have already conducted in different countries, but they lack any conclusive evidence of the adverse effects of EMF radiation on the human health⁹. The WHO established the International EMF Project in 1996 to assess the scientific evidence of any possible health effects from EMR in the frequency range - 0 to 300 GHz. In May 2006, WHO even released a fact sheet on “Electromagnetic fields radiation and public health: Base stations and wireless technologies” wherein it held that there is no convincing scientific evidence that the weak RF signals from wireless networks and mobile phone towers cause adverse health effects considering the very low exposure levels and results collected from the research¹⁰⁻¹².

WHO in September 2013 stated that while it is not established that use of mobile phones poses an increased risk of brain²⁰ tumors, but the increasing use of mobile phones and the lack of data available for mobile phone use for periods longer than 15 years points that further research is needed for mobile phone use and brain^{21,22} cancer risk. With the increasing popularity of mobile phone use among the younger generation, a potentially longer lifetime of exposure will be there. WHO has been promoting further research on this group of individuals and is currently assessing the health impact of the RF fields on all studied endpoints.²⁵⁻²⁶

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.”

There have been some arguments that EMF radiation has the potential even to mutate DNA and cause cancer. However, a certain threshold energy (energy per photon) is needed to mutate a DNA. Generally, the EM radiation with photonic energy of more than 10 eV is considered ionizing. Water requires about 12eV to ionize. Visible light photons carry about 2eV of energy while EM radiation photons at 300 GHz have approximately only 1.24 meV of energy. Thus, EM radiation from cellular operations does not have

enough energy to cause ionization or break the chemical bonds. Therefore, the diseases like cancer cannot be directly attributed to EM radiation originating from the communication infrastructure.

Dielectric heating, a potentially harmful effect of radio-frequency radiation comes from the absorption of EM radiation. But if the increase in temperature is small, the brain blood circulation is capable of disposing of this excess heat by increasing the local blood flow. Thus, the normal cellular response does not have any adverse effect on the body. There are some arguments that claim there are other various symptoms like sleep disturbance, fatigue, disturbance indigestion, loss of memory, etc. which have been caused due to exposure to the low-level EM radiation from the wireless devices in question.²⁸

There is, however, no scientific basis or diagnostic criteria that link EHS symptoms to EM radiation. Also, EHS is neither a medical diagnosis nor is it clear that it represents only a single medical problem. A number of studies have continuously reported some link between the occurrence of a variety of health disorders and exposure to EMF radiation, though these studies are considered inconclusive. The US National Cancer Institute has also concluded that there is no clear danger of cancer from mobile phone radiation.

*Published results*³⁰

1. In some of the experiments conducted on rats, it was suggested that EM radiation could affect the reproductive health of rats (ICMR and CSIR funded JNU study).
2. However, the results of such experiments were not published in any peer-reviewed international journal. Therefore, the credibility of the report can not be conclusively established. The claim regarding the formation of free radicals due to long exposure of rats to EMF from cell phones is also not substantiated.
3. There exist reports of harmful effects of EM radiation on bees, birds, etc. Animals that depend on the natural magnetic, electrical and electromagnetic fields for their orientation and navigation through earth's atmosphere can be confused by the much stronger and constantly changing artificial fields created by technology and can thus fail to navigate back to their home environ-

ments. A study was conducted in Germany to find whether there is any connection between CCD and radiation effects.

The study examined if a particular type of base station for mobile phones could affect honey bee homing systems. The causality was however not conclusively established viz. the base station had nothing to do with CCD. The researcher - Stefan Kimmel, who conducted the study and wrote the paper, e-mailed 'The Associated Press' and said that there was no link between their tiny little study and CCD-phenomenon and anything else said or written was a lie. In addition, apiaries are often located in rural areas, and the cell phone coverage there can be spotty. This makes cell phones or cell towers quite unlikely to cause CCD behavior in a substantial manner^{15,16}. During the usage of a cell phone by a person, most of the heating effect can be seen on the surface of the head which causes its temperature to increase by a fraction of a degree. In this case, the increase in temperature observed is less in magnitude than the one obtained during the exposure of the head to direct sunlight.

Here, the brain's blood circulation disposes of excess heat by increasing the local blood flow. The cornea of the eye, however, does not have this kind of temperature regulation mechanism and thus any exposure of 2–3 hours duration have been reported to produce cataracts in a rabbits' eyes at SAR values ranging in 100-140W/kg, which can produce lenticular temperatures of 41°C. However, no cataract was detected in the eyes of monkeys who were also exposed to similar conditions.

4. Another study, published in early 2001, in the Journal of the American Medical Association, conducted using positron emission tomography and fluorodeoxyglucose injections concluded that an increase in levels of glucose metabolism is observed within the parts of the brain that are closest to the cell phone antenna when exposure to radiofrequency signal waves. The clinical significance of this findings remains unknown.

5. Swedish researchers from Lund University had studied the effects of the microwave radiation on the rat brain. Their findings revealed a leakage of albumin into the brain through a permeated blood–brain barrier. This confirms the earlier work on the blood–brain barrier by Allan Frey, Albert and Kerns, and Oscar and

Hawkins. Other groups doing similar studies have not confirmed these findings in vitro cell studies or whole animal studies. However, Frey has alleged that an editor determined that a researcher who had claimed that his attempts to replicate Frey's research did not validate Frey's results, had incorrectly interpreted his own results and that his research, in fact, had confirmed Frey's results.

6. The EMF radiation exposure is directly related to the usage of the mobile handsets. In India as per December 2013 data, the Minutes of Usage (MOU) per subscriber is only 230 minutes per month for CDMA and 379 minutes per month for GSM. This means the average time the cell phones are near the head is only 12.6 minutes in a day. Hence, the exposure to the EMF radiation is considerably low.

7. Several surveys have found a variety of self-reported symptoms that include sleeping problems, subjective symptoms, and cognitive performance for people who live in the close proximity to the base stations.

Conclusion

The electromagnetic radiation coming from the cell towers and mobile phones are harmful as they affect the human health adversely. Scientists around the world have performed and documented several experiments that confirm these claims of radiations to be hazardous in nature. They have advised certain norms that are implemented to reduce these affects pertaining to the strength of the emitted signal, safe distance from the towers, etc. The existing norms in India are more stringent than other countries. However their implementation at the ground level is a crucial aspect and should be enforced strictly.

The continuous usage of the mobile devices for longer periods increases the risk many folds. Hence, it is advised to limit the use of the mobile phones and the durations of the exposure should be kept short. Furthermore, users are advised to use the messaging services like SMS whenever possible. The use of landlines instead of the mobile phones is surely a better choice to avoid the radiation from the mobile phones altogether. While in a call, it is better to use speakerphone or wired hands-free and keep the phone at least 1 feet away.

When not in use, the mobile phone should be kept far away from your body. It is advised not to keep the mobile phones in pockets, under your pillow, etc. All the cordless devices should be kept at a safe distance when sleeping. Only mobile phones having 'SAR' value less than 1.6 W/kg should be used. Mobile phones should not be placed directly over devices like pacemakers. When the radio signal is weak, the mobile phone increases its transmission power in an attempt to provide better connectivity; therefore, it is advised to use phones only where the network reception is good, the signal is strong. While using the phone, movement should be restricted as much as possible as it leads to higher intensity of radiation due to more transmission power as explained above.

Recommendations :

People should know about the radiation effect caused by the mobile and mobile tower. There is a need to educate everyone so that they can at least take precautions to reduce the effect of these harmful radiations. Awareness programmes can be organised to spread the message across with the plausible remedies. The government should work towards strictly applying better and improved radiation norms with immediate effect. We should work towards adopting the safe radiation level up to 0.001 W/m². Mobile phone technology should further evolve to limit the SAR value on the mobile handset. The mobile towers should increasingly switch to lesser transmitted power. The feasibility studies of an alternative technology that can eliminate or at least reduce these health hazards should be encouraged.

The exposure of the community to RF radiation to be minimized by carefully planning the placement and power level of the towers. The radiation level should be monitored in the community, and immediate rectification steps should be taken up if radiation levels are found to be improper and excessive beyond the safe limit. Strict penalties and fines should be levied on the offenders of the norms established in this domain. Incentives can also be provided to the telecom players to work towards minimizing the health hazards and provide a safer environment to the people.

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