

# EMF Pollution – Causes, Effects and Protection (Case Study)

Manoj V<sup>1</sup>, Naveenkumara A<sup>2</sup>, M Revanasiddappa<sup>3</sup>

<sup>1,2</sup>PESIT – Bangalore South Campus, Hosur Road, Bangalore 560 100, Department of Electronics and Communication Engineering

<sup>3</sup>PESIT – Bangalore South Campus, Hosur Road, Bangalore 560 100, Department of Engineering Chemistry

**Abstract:** *In modern day's high tech world, all of us are constantly experiencing EM radiation from almost all sources. Each and every source introduce its own EMF. At this very moment as you are reading this paper, you are probably being exposed to many electromagnetic fields. The situation is no different while we are at play, travelling, at work, reposing at home, and even sleeping on bed. Practically there is an increase in EMR pollution with the increase in every new invention. EMR of all frequencies serve as one of the fastest growing and most common environmental impacts, about which speculation and anxiety are growing. The digital communication devices which we use emit digital pulsed radio-frequency EMFs which are perhaps one of the most harmful kind for human health. In today's world use of cell phone has become ubiquitous with an estimated subscription of 6.9 billion globally. In modern day telecommunication cell phones play a very crucial role. It is not astonishing that the level of invisible electromagnetic pollution on our planet is tremendously high. As a result it is essential to examine, discern and check any possible impact on public health. The leading aim of this paper is to examine the harmful impacts of the electromagnetic radiation, survey the regulations which are in place to keep a check on the levels of radiations and to suggest a few daily habits which will help to reduce one's exposure to such harmful radiations.*

**Keywords:** Electromagnetic field (EMF), Electromagnetic radiation (EMR), Electromagnetic compatibility (EMC), Interference (EMI)

## 1. Introduction

Electromagnetic compatibility is defined as the capability of the systems and devices to operate in their electromagnetic environment without debilitating in their functions. EMC is the idea of enabling electronic devices to operate without mutual interference - Electromagnetic Interference (EMI) - when they are operated in close proximity to each other.

All electronic circuits have a high possibility of picking up and radiating undesired electrical interferences which may hinder the working of the circuits. Electromagnetic compatibility(EMC) ensures that the operation of one device does not impact the surrounding electromagnetic environment to such an extent that the functions of other systems and devices are adversely affected. Usage of electronic devices in military applications was one of the early and notable concerns of the effects of EMI on electronic systems. With the rise in emphasis on nuclear weapons after the Second World War the effects of electronic pulse generated by an explosion and high powered radar systems on equipment became a concern. Some of the ill effects it had on the surrounding devices were that it could set false triggers and sometimes even damage the device. During the 1970s the use of logic circuitry grew rapidly which led to higher switching speeds. This made these circuits more vulnerable to the effects of EMI, and the need for EMC precautions to be incorporated into the design grew, if these devices had to work satisfactorily in the real world.

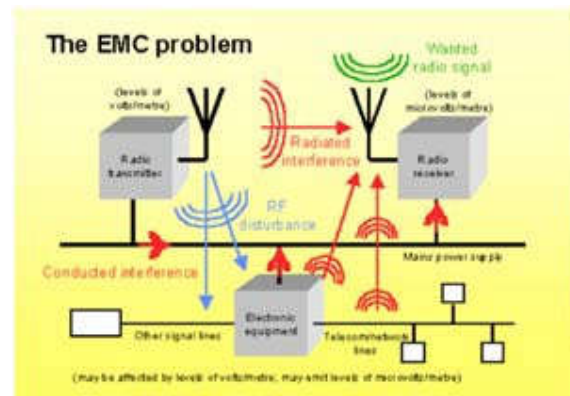


Figure 1:Block diagram of EMC problem

## 2. EMI and EMF pollution

The unwanted electromagnetic radiation that causes potential interference to other electronic equipment is known as Electromagnetic interference (EMI). A susceptible victim detects the interference produced by a source emitter via a coupling path.

EMI can be broadly divided into two categories:

### 2.1 Continuous interference

A maintained form of oscillation or radio signal is a common example of continuous interference. It may be in the form of wideband noise or even from an unshielded oscillator.

### 2.2 Impulse interference

This form of interference consists of a short impulse. Some of its sources are lightning, electrostatic discharge, and a circuit

being switched.

One effective method to reduce EMI is the spread spectrum technique in which the signal is modulated and its energy is spread over a wider range of frequency. Spread Spectrum is a careful and controlled modulation of the clock signal in such a way that it does not contribute significantly to jitter. As available band width increases the numbers of users also increase. Therefore this will lead to a loop of sequence.

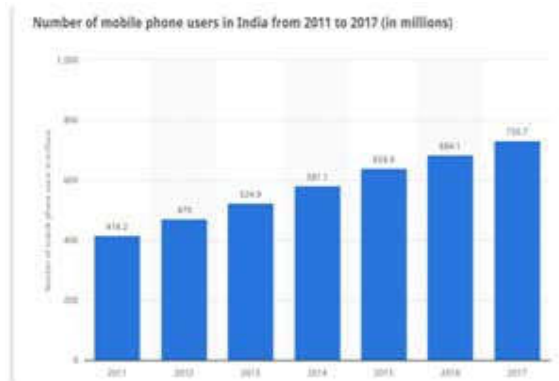


Figure 2: Number of mobile users in India from 2011 to 2017 (in millions)

### 3. Case study

The electromagnetic fields experienced from a strong radiation source that is far away is much lesser compared to the electromagnetic fields experienced from a weak radiation source that is close by. The strongest EMF which we are experiencing is probably coming from a digital phone, computer or household appliance which are quite close to us.

Device	SAR (W/kg)
Motorola Droid	1.49
Blackberry Bold	1.43
Apple iPhone 4	1.17
Apple iPhone 4S	1.11
Samsung Galaxy S II	0.35
Bluetooth Device	~0.001
Wifi Router	~0.001

Table 1: SAR values of popular cell phone

Some of the important sources of electromagnetic field pollution are:

- cell phones
- Computers, wireless gaming consoles, base stations and related equipment
- electrical appliances (radio, TV, oven)
- information networks
- low and high-power lines
- house-wiring
- automobiles
- Smart meters that transmit radio signals.

Most of the above mentioned sources generate radio-frequency EMF, but some (for example power lines and house-wiring) produce low-frequency EMF. Radio-frequency EMF and low-frequency EMF both are harmful to human health.

Mobile phones transmit low-powered radio frequency. The market for mobile phones is rapidly growing and majority of the population use cell phones in most countries. There was an estimated 6.9 billion subscriptions in 2014, globally. EMC is of increasing importance as the number of wirelessly connected devices increase.

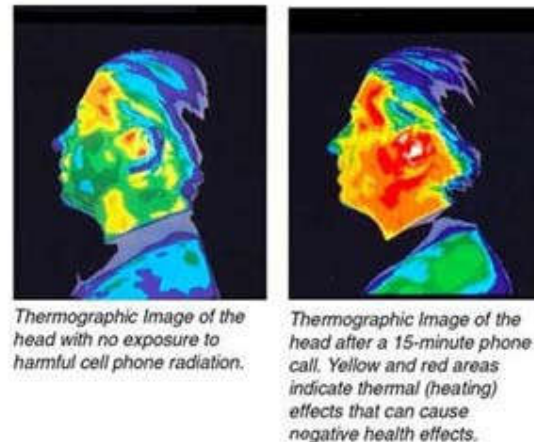


Figure 3: Thermographic image of head

### 4. Why does EMR affect our body?

An electric current is induced inside us when an electromagnetic wave passes through our body. Our body naturally uses electrical impulses for many purposes such as thinking, conveying sensory information, controlling heartbeats and initiating muscular movement. The chemical processes which take place in our cells, body tissues, organs and blood depend on electrical charges present within the body for their precise functioning. As a result when an electric current is created by the external EMF in our body it interferes with many of our biological processes. Increase in the temperature of body tissue is one of the major visible impacts of such radiations.

Though electromagnetic radiation is not necessarily all bad as few of the biological effects can be harnessed for constructive purposes like relieving pain, healing bone tissue and so on, the radiations that penetrate our bodies daily are far from beneficial. Initially which starts off causing unpleasant symptoms, at a later stage may lead to a more permanent health problem unless action is taken to limit exposure [7].

### 5. Types of hazards

#### 5.1 Electrical and fire hazards

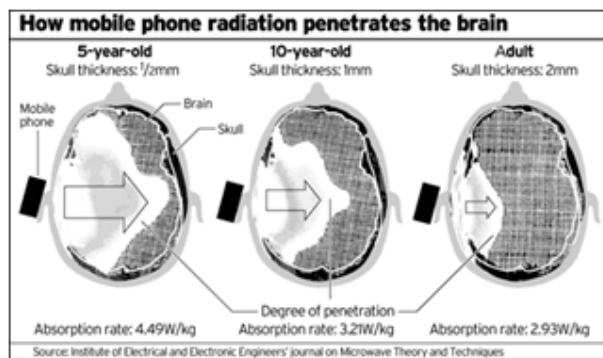
There are instances when a person has experienced an electric shock due to the current induced by very strong radiation. Chances of overloading and destruction of electronic devices in such situations are also high. Electromagnetic radiation of

high power can also generate electric currents which create sparks. This happens when the voltage induced due to EMR becomes comparatively greater than the surrounding medium's breakdown voltage (air at 3.0 MV/m). These sparks created by extremely high power EMR can in turn ignite flammable gases or materials, which may possibly lead to an explosion. This type of hazard can typically occur in the vicinity of pyrotechnics or explosives, since these materials can be easily ignited by such electrical overload. The United States navy refer to this risk commonly as Hazards of Electromagnetic Radiation to Ordnance [4].

### 5.2 Biological hazards

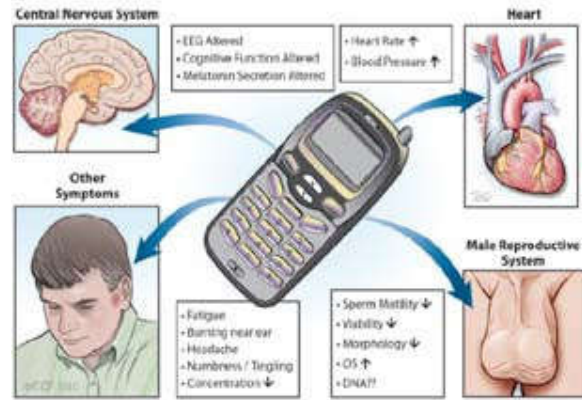
Excessive exposure to EMF pollution exhibits some of the following symptoms:

- Fatigue
- Concentration difficulties
- Depression
- Headaches
- Skin rashes
- Memory impairment
- Nausea
- Palpitations
- Sleep disturbance
- Anxiety



**Figure 5:**Penetration of mobile phone radiation in human brain

One of the thoroughly studied biological effects of EMFs is the dielectric heating of body tissue. To get an idea consider standing near or touching a high power transmitting antenna while it is in operation. Burns caused in the incidents involving MV ovens are very much similar to the burns caused in such circumstances. Most of the excruciating exposures to noxious levels of EMR are immediately felt as burning sensation, but the health effects due to prolong exposure (occupational or chronic) may not exhibit effects for long time. Dielectric heating depends on the frequency and power of the electromagnetic radiation. Specific absorption rate (SAR) is used as a measure of the heating effect. SAR has a unit of watts per kilogram (W/kg).



**Figure 4:**Some effects of prolonged use of cell phones

Reduction of excessive heat in the eyes and the testes is hard as they have lesser blood flow. As a result they are more susceptible to the heating effect of RF radiations. When testes is in constant exposure to high-energy radiation of radio-frequency, it results in temporary sterility due to the decrease in sperm count and its motility. Epidemiological studies in humans and scientific experiments conducted on animals have helped us recognize that one of the cause for cataracts is continuous exposure to high-levels of microwaves. This mechanism is obscure and under research but it is believed that the lens constitute certain cell proteins which are protected by heat sensitive enzymes. It is variations in this enzyme that results in cataracts. Exposure to adequately high-power MW radio frequency initiates effect which range from a burning sensation and blistering of the skin and auditory effect of microwave to acute pain at the mid-range.

There are papers that support the existence of complex biological effects caused due to weaker non-thermal electromagnetic fields, which include weak modulated microwave and RF fields. In 2009 a study at the University of Basel in Switzerland established that sporadic exposure of human cells to an electromagnetic field of 50Hz at a flux density of 1 MT engender a significant increase in fragmentation of DNA in the Comet assay. However the current established safety exposure limits are lesser than the above mentioned level of exposure.

### 6. The perils of electromagnetic radiation by cell phones

Mobile phones are considered dangerous as they emit powerful EMFs and are held close to the head or body for long duration of time [2].

- Electromagnetic radiations emitted from phone's antenna is very harmful.
- Radiation from cell phone antenna penetrates up to 2 inches into the adult brain depending on the duration of use of cell phone.
- Mobile phones cause heating up of biological tissues and also have non-thermal effects.
- Experiments have proven that poor rapid eye movement sleep causes impaired learning and memory which is linked to exposure to EMR when people sleep with a cell phone close to bed.

- Brainwaves are altered approximately 70% of the time the cell phone is held next to the head.

## 7. Effects of Fluorescent and LED lights

Fluorescent tubes and light bulbs internally produce ultraviolet light. Normally visible light is obtained from this by a phosphor film present inside a protective coating. Due to faulty manufacturing or mishandling of the film, the film might crack which leads to escape of ultraviolet light at levels that could cause sunburn or even skin cancer. The pineal gland produce a reduced quantity of melatonin and people observe poor sleeping periods due to failure of human's biological clock when exposed to blue light emitting wavelengths of 400–500 nanometers.

## 8. Safe levels of electromagnetic radiation

The US Federal Communications Commission (FCC) have set standards for the specific absorption rate (SAR) and those levels which are above these set standards are considered to be harmful. Exposure levels of up to a SAR level of 4W/kg is considered to be safe level to radio frequency and microwave radiation, which is considered to be the threshold level. Beyond this level body starts experiencing harmful thermal effects due to energy absorption. 0.4 W/kg SAR is the recommended protection guidelines keeping in mind a factor of ten to be on a safer side. Eastern European countries and Russia set different SAR thresholds which are lower than western countries. Different countries set different SAR standards especially with respect to low exposure levels [3].

### 8.1 International standards

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an organization of independent scientists in Europe which is funded publicly. This organization with the help of the Environmental Health Division of the World Health Organization (WHO) sets guidelines and spread information about the possible health impacts of exposure to non-ionizing radiation. In 1998 and 2009, the ICNIRP established and confirmed ground rules for limiting exposure to time-varying EMFs of up to 300 GHz. The current safety limit is 2.0 W/Kg in 10g of tissue [3].

### 8.2 Indian standards

Currently, considering radiation from mobile phone towers, permissible Power Density for 900MHz is 4.5 W/m<sup>2</sup> and for 1800MHz is 9 W/m<sup>2</sup>[3].

## 9. WHO's response

WHO has played its role in establishing the International EMF Project in 1996 [5]. This action helped scientists to investigate the scientific evidences of probable negative health impacts from EMFs. WHO is in the process of conducting risk assessment of all investigated health issues from RF field exposure and is determined to come out with concrete stats by 2016. Carcinogenic properties of RF fields radiated from cell phones is under review by a specialized agency - International Agency for Research on Cancer (IARC) [5].

WHO identifies and encourages scientist to take up research options and to educate others round the globe through its research agendas. Public information materials on this growing topic are being developed by WHO which also play a major role in setting a stage for the discussion among scholars, corporate, bureaucrats, and to increase awareness about the ill-effects of excessive use of mobile phones among common people.

## 10. Ways to reduce the effects of EMR

- It is advisable for the users of mobile phone to maintain at least 30–40 cm distance between phone and body as the radiation power decreases rapidly with increasing distance from the cell. Hence, someone holding the head set next to his head will be exposed to much larger amount of radiofrequency fields than someone who is holding it farther apart.
- Another important way to limit one's exposure to such radiations is to reduce the number and length of calls. Cell phones should be positioned in such a way that the antenna of the cell is facing away from us.
- Different types of fabrics are available which can be used to shield oneself from the harmful electromagnetic fields and radiations. Mesh type shielding fabrics are used for canopies, curtains, enclosures. Shielding fabrics with a natural feel and look made with bamboo fibre and silver are used for bedding, drapes, clothing, grounding, tents.
- We should avoid using phone when its battery is low or even when the signal reception is poor because they emit more radiation. On the other hand we should use them in areas of good reception where they transmit signals at reduced power. We should also avoid using cell phone in elevators, cars, trains and planes because they radiate and draw more power in a metal enclosed environment.
- Mainly on airplanes and in hospitals mobile phones are often prohibited as the RF signals emitted by them disrupt the working of navigation systems and electro-medical devices and.
- Clocks which are powered by battery are preferred and we should make sure that the extension cords do not spread under or around the bed and also proper care must be taken to avoid electric blankets and wired mattress warmers.
- Use of an Ethernet cord instead of a wireless router to connect to the internet should be highly discouraged. Using wired computer peripherals like mouse, keyboard and printers are good options. It is better to disconnect Wi-Fi enabled devices, before going to bed and house the router away from children's room and desk.
- While choosing electronic devices like TV, proper precaution must be taken in choosing a LCD in place of old cathode ray tube models or plasma models as the amount of radiation from the LCD is much lesser compared to others.
- Other materials which can be used as fabric to shield from electromagnetic radiation are –alternative layer of pure cotton and silver, surgical stainless steel knitted fabric, a polyester substrate, plated with nickel and copper, etc [6].

## 11. Acknowledgement

The authors acknowledge Vision Group on Science and Technology, Government of Karnataka, Bangalore, for providing financial assistance in the form of a research and

establishment of infrastructure (No.: VGST/K-FIST(L<sub>1</sub>)/GRD-363/2014-2015 dated 02 Jan. 2015).

## 12. Conclusion

The entire population is susceptible to various degrees of radiation, and the increasing level of EMR is directly dependent on the advancement in technology. Hence we should all act collectively to minimize further growth. There is an increase in the number of situations related to negative health effects due to exposure to EMFs which is becoming more clear and difficult to ignore. Unless the public dedicate considerable amount of time and take initiative to learn and educate others as well about EMF and EMR, it is hard to find cleaner and healthier alternatives. The average level of EMF we experience today is estimated to be fifty times greater than what our parents experienced at the same age. Should today's children experience fifty times more electromagnetic fields than we do now? Raphael Siket once rightly said "Improving the air you breathe, the water you drink and the products you use, Benefits the life you lead, the generations to come and the planet as a whole".

## Reference

- [1] "Wiley encyclopaedia of biomedical engineering" - Ferransilva, Mireya Fernandez, Pere J. Riu
- [2] "Electromagnetic fields and public health: mobile phones - Fact sheet N°193" - World Health Organization.
- [3] Ivan Figueroa-Otera, Associate Professor of Surgery What are safe levels of electromagnetic radiation? - <http://www.slideshare.net/ivanfigueroaotero/electromagnetic-pollution-and-its-health-effects-on-the-13565533?related=3>
- [4] "Biological Effects of Power Frequency Electric and Magnetic Fields" – Indira Nair, M Granger Morgan, H Keith Florog
- [5] Information page on electromagnetic fields at the World Health Organization web site.
- [6] <https://environmentofearth.wordpress.com/2012/04/19/electromagnetic-pollution/>
- [7] "Telegram Regulatory Authority of India (TRAI) on Effects of Electromagnetic Field Radiation from Mobile Towers and Handsets" - Information paper No: 01/2014 – QoS.
- [8] <http://www.slideshare.net/ivanfigueroaotero/electromagnetic-pollution-and-its-health-effects-on-the-13565533?related=3>
- [9] "Electromagnetic Fields in Biological Systems" Spans a variety of topics, from static fields to terahertz waves By James C. L
- [10] "Magnetic Resonance Procedures: Health Effects and Safety" Edited by Frank G. Shellock.