# DELHI TECHNOLOGICAL UNIVERSITY

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## TOPIC: Detailed Report on HARMFUL EFFECTS of ELECTROMAGNETIC RADIATION


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# INTRODUCTION

You cannot see it, taste it or smell it, but it is one of the most pervasive environmental exposures in industrialized countries today. Electromagnetic radiation (EMR) or electromagnetic fields (EMFs) are the terms that broadly describe exposures created by the vast array of wired and wireless technologies that have altered the landscape of our lives in countless beneficial ways. However, these technologies were designed to maximize energy efficiency and convenience; not with biological effects on people in mind. Based on new studies, there is growing evidence among scientists and the public about possible health risks associated with these technologies.

Human beings are bioelectrical systems. Internal bioelectrical signals regulate our hearts and brains. Environmental exposures to artificial EMFs can interact with fundamental biological processes in the human body. In some cases, this can cause discomfort and disease. Since World War II, the background level of EMF from electrical sources has risen exponentially, most recently by the soaring popularity of wireless technologies such as cell phones (two billion and counting in 2006), cordless phones, WI-FI and WI-MAX networks. Several decades of international scientific research confirm that EMFs are biologically active in animals and in humans, which could have major public health consequences.

In today's world, everyone is exposed to two types of EMFs ~.

1) shallow frequency electromagnetic fields (extremely low frequency electromagnetic fields) from electrical and electronic appliances and power lines

2) radiofrequency radiation (RF) from wireless devices such as cell phones and cordless phones, cellular antennas and towers, and broadcast transmission towers.

They are both types of non-ionizing radiation, which means that they do not have sufficient energy to break off electrons from their orbits around atoms and ionize (charge) the atoms, as do x-rays, CT scans, and other forms of ionizing radiation.

# NEED FOR THE TOPIC

In today's world, wireless technologies have become very common. People nowadays can be seen using standard devices that make use of wireless networks like cellular networks, WIFI, Bluetooth to an advancing technological generation using wireless devices like mouse, keyboards, earphones and even more advanced wireless technologies are being developed and improved like wireless Charging which incorporates Wireless Electricity or WiTricity.
In-fact I have used a wireless mouse and a wireless keyboard for preparing this project report which might seem ironical. Still, the purpose of this topic is not to eradicate the facilities that are provided to us by wireless technology in our day to day lives.

The wireless technologies have advanced a lot over a few decades. The rapid increase in this field has also led to an increase in demands by the users of this technology and a subsequent increase in the competition in the market.

The main focus of this field of technology has shifted to increasing the range of connectivity and increased power of the signal to improve better network stability and faster speeds of communication.

Neglecting the side-effects of EMF radiation has led to a decreased average lifespan of human beings. This has always been a topic of conversation in our families as to how our fathers and great grand-fathers lived a long life-span of 100 years or even greater in some families which has now reduced to an average life-span of 70 years at maximum.
Amidst this rush, the technologies have provided us a comfortable way of life but at the same time clouded our vision to judge their harmful effects on Humans and its surrounding environment.

The purpose of this project is to highlight the factors that affect humans and environment, the effects of these factors on our health and nature, the current safety parameters being applied to this technology and also to suggest ways of improvisation in these safety parameters to ensure a healthy future generation.

# Electromagnetic Radiations Around Us

## 1. Background electromagnetic field levels from electricity transmission and distribution facilities

Electricity is transmitted over long distances via high voltage power lines. Transformers reduce these high voltages for local distribution to homes and businesses. Electricity transmission and distribution facilities and residential wiring and appliances account for the background level of power frequency electric and magnetic fields in the house. In homes not located near power lines this background field may be up to about 0.2 μT. Directly beneath power lines the areas are much stronger. Magnetic flux densities at ground level can range up to several μT. Electric field levels underneath power lines can be as high as ten kV/m. However, the fields (both electric and magnetic) drop off with distance from the lines. At 50 m to 100 m distance, the fields are normally at levels that are found in areas away from high voltage power lines. Also, house walls substantially reduce the electric field levels from those found at similar locations outside the house.

## 2. Electric appliances in the household

The strongest power frequency electric fields that are ordinarily encountered in the environment exist beneath high voltage transmission lines. In contrast, the strongest magnetic fields at power frequency are normally found very close to motors and other electrical appliances, as well as in specialized equipment such as magnetic resonance scanners used for medical imaging.

**Typical electric field strengths measured near household appliances (at a distance of 30 cm) (From: Federal Office for Radiation Safety, Germany 1999)**

| Electric appliance | Electric field strength (V/m) |
|---|---|
| Stereo receiver | 180 |
| Iron | 120 |
| Refrigerator | 120 |
| Mixer | 100 |
| Toaster | 80 |
| Hair dryer | 80 |
| Colour TV | 60 |
| Coffee machine | 60 |
| Vacuum cleaner | 50 |
| Electric oven | 8 |
| Light bulb | 5 |
| **Guideline limit value** | **5000** |

Many people are surprised when they become aware of the variety of magnetic field levels found near various appliances. Even between apparently similar devices, the strength of the magnetic field may vary a lot. For example, while some hair dryers are surrounded by a very strong field, others hardly produce any magnetic field at all. These differences in magnetic field strength are related to product design. The following table shows typical values for a number of electrical devices commonly found in homes and workplaces. The measurements were taken in Germany and all of the appliances operate on electricity at a frequency of 50 Hz. It should be noted that the actual exposure levels vary considerably depending on the model of appliance and distance from it.

| Electric appliance | 3 cm distance (µT) | 30 cm distance (µT) |
|---|---|---|
| Hair dryer | 6 – 2000 | 0.01 – 7 |
| Electric shaver | 15 – 1500 | 0.08 – 9 |
| Vacuum cleaner | 200 – 800 | 2 – 20 |
| Fluorescent light | 40 – 400 | 0.5 – 2 |
| Microwave oven | 73 – 200 | 4 – 8 |
| Portable radio | 16 – 56 | 1 |
| Electric oven | 1 – 50 | 0.15 – 0.5 |
| Washing machine | 0.8 – 50 | 0.15 – 3 |
| Iron | 8 – 30 | 0.12 – 0.3 |
| Dishwasher | 3.5 – 20 | 0.6 – 3 |
| Computer | 0.5 – 30 | < 0.01 |
| Refrigerator | 0.5 – 1.7 | 0.01 – 0.25 |
| Colour TV | 2.5 - 50 | 0.04 – 2 |

## 2.1 Television sets and computer screens

Computer screens and television sets work on similar principles. Both produce static electric fields and alternating electric and magnetic fields at various frequencies. However, screens with liquid crystal displays used in some laptop computers and desktop units do not give rise to significant electric and magnetic fields. Modern computers have conductive nets which reduce the static field from the screen to a level similar to that of the standard background in the home or workplace. At the position of operators (30 to 50 cm from the screen), alternating magnetic fields are typically below 0.7 μT in flux density (at power frequencies). Alternating electric field strengths at operator positions range from below 1 V/m up to 10 V/m.

## 2.2 Microwave ovens

Domestic microwave ovens operate at very high-power levels. However, effective shielding reduces leakage outside the ovens to almost non-detectable levels. Further-more microwave leakage falls very rapidly with increasing distance from the oven. Many countries have manufacturing standards that specify maximum leakage levels for new ovens; an oven that meets the manufacturing standards will not present any hazard to the consumer.

## 2.3 Portable telephones

Portable telephones operate at much lower intensities than mobile phones. This is because they are employed very close to their home base station, and so do not need strong fields to transmit over long distances. As a consequence, the radiofrequency fields that surround these devices are negligible.


Figure 2.1

Figure 2.2

Figure 2.3

# 3. Electromagnetic fields in the environment

## 3.1 Radar

Radars are used for navigation, weather forecasting, and military applications, as well as a variety of other functions. They emit pulsed microwave signals. The peak power in the pulse can be high even though the average power may be low. Many radars rotate or move up and down; this reduces the mean power density to which the public is exposed in the vicinity of radars. Even high power, non-rotating military radars limit exposures to below guideline levels at locations of public access.

## 3.2 Security systems

Anti-theft systems in shops use tags that are detected by electrical coils at the exits. When a purchase is made the tags are removed or permanently deactivated. The electromagnetic fields from the coils do not generally exceed exposure guideline levels. Access control systems work in the same way with the tag incorporated into a key ring or identity card. Library security systems use tags that can be deactivated when a book is borrowed and reactivated when it is returned. Metal detectors and airport security systems set up a strong magnetic field of up to 100 μT that is disturbed by the presence of a metal object. Close to the frame of the detector, magnetic field strengths may approach and occasionally exceed guideline levels. However, this does not constitute a health hazard, as will be discussed in the section on guidelines.

Figure 3.2 EMF from airport body scanners

### 3.3 Electric a)Trains and b)Trams

Long-distance trains have one or more engine cars that are separate from the passenger cars. Thus, passenger exposure comes mainly from the electricity supply to the train. Magnetic fields in the passenger cars of long-distance trains can be several hundred μT near the floor, with lower values (tens of μT) elsewhere in the compartment. Electric field strengths may reach 300 V/m. People living in the vicinity of railway lines may encounter magnetic fields from the overhead supply which, depending on the country, may be comparable to the fields produced by high-voltage power lines.

Figure 3.3 a)

Figure 3.3 b)

Motors and traction equipment of trains and trams are normally located underneath the floors of passenger cars. At floor level, magnetic field intensities may amount to tens of μT in regions of the floor just above the motor. The fields fall off quickly with distance from the floor, and exposure of the upper bodies of passengers is much lower.

### 3.4 TV and radio

When choosing a radio station on your stereo at home, have you ever wondered what the familiar abbreviations AM and FM stand for? Radio signals are described as amplitude-modulated (AM) or frequency-modulated (FM) depending on the way in which they carry information. AM radio signals can be used for broadcasting over very long distances whereas FM waves cover more localized areas but can give a better sound quality.

AM radio signals are transmitted via large arrays of antennas, which can be tens of meters high, on sites which are off-limits to the public. Exposures very close to antennas and feed cables can be high, but these would affect maintenance workers rather than the general public.

TV and FM radio antennas are much smaller than AM radio antennas and are mounted in arrays at the top of high towers. The towers themselves serve only as supporting structures. As exposures near the foot of these towers are below guideline limits, public access to these areas may be possible. Small local TV and radio antennas are sometimes mounted on the top of buildings; if this is the case it may be necessary to control access to the roof.

**3.5) Mobile phones and their base stations**

Mobile phones allow people to be within reach at all times. These low-power radio-wave devices transmit and receive signals from a network of fixed low power base stations. Each base station provides coverage to a given area. Depending on the number of calls being handled, base stations may be from only a few hundred meters apart in major cities to several kilometers apart in rural areas.

Mobile phone base stations are usually mounted on the tops of buildings or on towers at heights of between 15 and 50 meters. The levels of transmissions from any particular base station are variable and depend on the number of calls and the callers' distance from the base station. Antennas emit a very narrow beam of radio-waves which spreads out almost parallel to the ground. Therefore, radiofrequency fields at ground level and in regions normally accessible to the public are many times below hazard levels. Guidelines would only be exceeded if a person were to approach to within a meter or two directly in front of the antennas. Until mobile phones became widely used, members of the public were mainly exposed to radiofrequency emissions from radio and TV stations. Even today, the phone towers themselves add little to our total exposure, as signal strengths in places of public access are normally similar to or lower than those from distant radio and TV stations.

However, the user of a mobile phone is exposed to radiofrequency fields much higher than those found in the general environment. Mobile phones are operated very close to the head. Therefore, rather than looking at the heating effect across the whole body, the distribution of absorbed energy in the head of the user must be determined. From sophisticated computer modelling and measurements using models of heads, it appears that the energy absorbed from a mobile phone is not in excess of current guidelines.

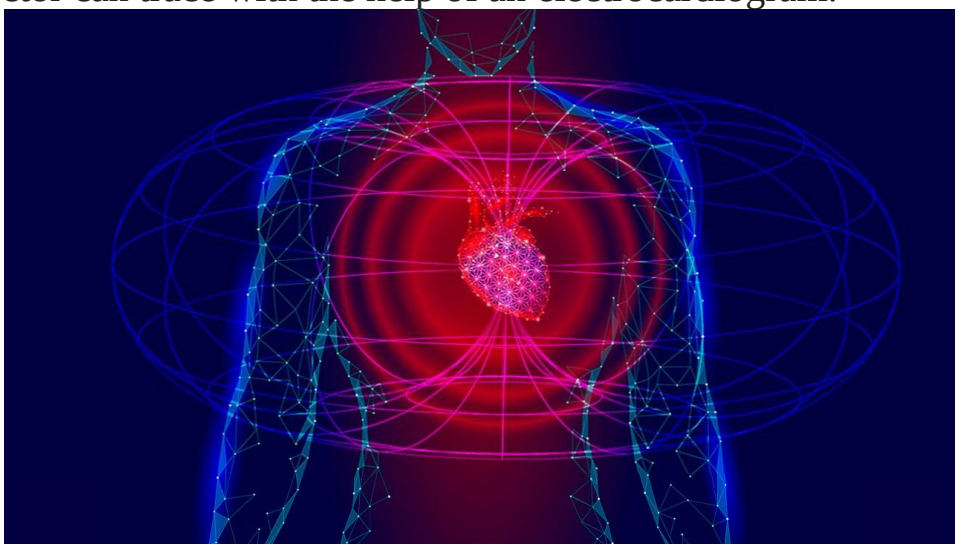
Concerns about other so-called non-thermal effects arising from exposure to mobile phone frequencies have also been raised. These include suggestions of subtle effects on cells that could have an effect on cancer development. Effects on electrically excitable tissues that may influence the function of the brain and nervous tissue have also been hypothesized. However, the overall evidence available to date does not suggest that the use of mobile phones has any detrimental effect on human health.

It has still been found that switching to airplane mode reduces most of the exposure from using mobile phones.

# What happens when you are exposed to electromagnetic fields?

Exposure to electromagnetic fields is not a new phenomenon. However, during the 20th century, environmental exposure to human-made electromagnetic fields has been steadily increasing as growing electricity demand, ever-advancing technologies and changes in social behavior have created more and more artificial sources. Everyone is exposed to a complex mix of weak electric and magnetic fields, both at home and at work, from the generation and transmission of electricity, domestic appliances and industrial equipment, to telecommunications and broadcasting.

Tiny electrical currents exist in the human body due to the chemical reactions that occur as part of the normal bodily functions, even in the absence of external electric fields. For example, nerves relay signals by transmitting electric impulses. Most biochemical reactions from digestion to brain activities go along with the rearrangement of charged particles. Even the heart is electrically active - an activity that your doctor can trace with the help of an electrocardiogram.



Low-frequency electric fields influence the human body just as they influence any other material made up of charged particles. When electric fields act on conductive materials, they influence the distribution of electric charges at their surface. They cause current to flow through the body to the ground.

Low-frequency magnetic fields induce circulating currents within the human body. The strength of these currents depends on the intensity of the outside magnetic field. If sufficiently large, these currents could cause stimulation of nerves and muscles or affect other biological processes.
Both electric and magnetic fields induce voltages and currents in the body but even directly beneath a high voltage transmission line, the induced currents are very small compared to thresholds for producing shock and other electrical effects.

Heating is the main biological effect of the electromagnetic fields of radiofrequency fields. In microwave ovens this fact is employed to warm up food. The levels of radiofrequency fields to which people are normally exposed are very much lower than those needed to produce significant heating. The heating effect of radio-waves forms the underlying basis for current guidelines. Scientists are also investigating the possibility that effects below the threshold level for body heating occur as a result of long-term exposure. To date, no adverse health effects from low level, long-term exposure to radiofrequency or power frequency fields have been confirmed, but scientists are actively continuing to research this area.

# Biological Effects of Long Exposures to Electromagnetic Fields

Long exposures to electromagnetic fields can lead to various biological effects and diseases. Long exposure of electromagnetic fields can affect people of all age groups. Long exposures to electromagnetic fields can result in many chronic diseases such as -

**1. Childhood Cancers**
The evidence that power lines and other sources of extremely low-frequency electromagnetic fields are consistently associated with higher rates of childhood leukemia has resulted in the International Agency for Cancer Research (an arm of the World Health Organization) to classify extremely low frequency electromagnetic fields as a Possible Human Carcinogen (in the Group 2B carcinogen list).

Leukemia is the most common type of cancer in children. Several recent studies provide even stronger evidence that extremely low frequency electromagnetic fields is a risk factor for childhood leukemia and cancers later in life.

It has been found that children who were recovering in high-extremely low frequency electromagnetic fields environments i.e. 3mG and above had 450% increased risk of dying. Moreover, children recovering in 2 mG and above extremely low frequency electromagnetic fields environments were 300% more likely to die than children exposed to 1 mG and below. Children recovering in extremely low frequency electromagnetic fields environments between 1 and 2 mG also had poorer survival rates, where the increased risk of dying was 280%.

These statistics give a solid proof that even extremely low frequency electromagnetic fields exposures in children can be harmful at levels above even 1 mG.

In a study that studied about the risks of long term cancer in children exposed to extremely low frequency electromagnetic fields environments in the early stages of their life found that risks for cancer would have later in life, if that child was raised in a home within 300 meters of a high-voltage electric power line,  they have a life-time risk that is 500% higher for developing some kinds of cancers.

Given the extensive study of childhood leukemia risks associated with extremely low frequency electromagnetic fields, and the relatively consistent findings that exposures in the 2 mG to 4 mG range are associated with increased risk to children, a 1 mG limit for habitable space is recommended for new construction. While it is difficult and expensive to retrofit existing habitable space to a 1 mG level, and is also recommended as a desirable target for existing residences and places where children and pregnant women may spend prolonged periods of time.

**Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure**
**(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)**

| Power Density (Microwatts/centimeter2 - uW/cm2) | | Reference |
|---|---|---|
| 0.01 - 0.05 uW/cm2 | Adults (18-91 yrs) with short-term exposure to GSM cell phone radiation reported headache, neurological problems, sleep and concentration problems. | Hutter, 2006 |
| 0.005 - 0.04 uW/cm2 | Adults exposed to short-term cell phone radiation reported headaches, concentration difficulties (differences not significant, but elevated) | Thomas, 2008 |
| 0.015 - 0.21 uW/cm2 | Adults exposed to short-term GSM 900 radiation reported changes in mental state (e.g., calmness) but limitations of study on language descriptors prevented refined word choices (stupified, zoned-out) | Augner, 2009 |
| 0.05 - 0.1 uW/cm2 | RFR linked to adverse neurological, cardio symptoms and cancer risk | Khurana, 2010 |
| 0.05 - 0.1 uW/cm2 | RFR related to headache, concentration and sleeping problems, fatigue | Kundi, 2009 |
| 0.07 - 0.1 uW/cm2 | Sperm head abnormalities in mice exposed for 6-months to base station level RF/MW. Sperm head abnormalities occurred in 39% to 46% exposed mice (only 2% in controls) abnormalities was also found to be dose dependent. The implications of the pin-head and banana-shaped sperm head. The occurrence of sperm head observed increase occurrence of sperm head abnormalities on the reproductive health of humans living in close proximity to GSM base stations were discussed." | Otitoloju, 2010 |
| 0.38 uW/cm2 | RFR affected calcium metabolism in heart cells | Schwartz, 1990 |
| 0.8 - 10 uW/cm2 | RFR caused emotional behavior changes, free-radical damage by super-weak MWs | Akoev, 2002 |
| 0.13 uW/cm2 | RFR from 3G cell towers decreased cognition, well-being | Zwamborn, 2003 |
| 0.16 uW/cm2 | Motor function, memory and attention of school children affected (Latvia) | Kolodynski, 1996 |
| 0.168 - 1.053 uW/cm2 | Irreversible infertility in mice after 5 generations of exposure to RFR from an 'antenna park' | Magras & Zenos, 1997 |
| 0.2 - 8 uW/cm2 | RFR caused a two-fold increase in leukemia in children | Hocking, 1996 |
| 0.2 - 8 uW/cm2 | RFR decreased survival in children with leukemia | Hocking, 2000 |
| 0.21 - 1.28 uW/cm2 | Adolescents and adults exposed only 45 min to UMTS cell phone radiation reported increases In headaches. | Riddervold, 2008 |

## 2. Brain Tumors and Acoustic Neuromas

Radiofrequency radiation from cell phone and cordless phone exposure has been linked to increased risk for brain tumors and/or acoustic neuromas (a tumor in the brain on a nerve related to our hearing).

For brain tumors, people who have used a cell phone for 10 years or longer have a 20% increase in risk (when the cell phone is used on both sides of the head). For people who have used a cell phone for 10 years or longer predominantly on one side of the head, there is a 200% increased risk of a brain tumor.

The risk of brain tumor (high-grade malignant glioma) from cordless phone use is 220% higher (both sides of the head). The risk from use of a cordless phone is 470% higher when used mostly on only one side of the head.

For acoustic neuromas, there is a 30% increased risk with cell phone use at ten years and longer; and a 240% increased risk of acoustic neuroma when the cell phone is used mainly on one side of the head.

**3. Breast Cancer**

Numerous studies show that long exposure to extremely low frequency electromagnetic fields can result in breast cancer in both men and women. Breast cancer studies of people who work in relatively high ELF exposures (10 mG and above) show higher rates of this disease.

Most studies of workers who are exposed to ELF have defined high exposure levels to be somewhere between 2 mG and 10 mG. Laboratory studies that examine human breast cancer cells have shown that ELF exposure between 6 mG and 12 mG can interfere with protective effects of melatonin that fights the growth of these breast cancer cells.

For a decade, there has been evidence that human breast cancer cells grow faster if exposed to ELF at low environmental levels. This is thought to be because ELF exposure can reduce melatonin levels in the body. The presence of melatonin in breast cancer cell cultures is known to reduce the growth of cancer cells. The absence of melatonin (because of ELF exposure or other reasons) is known to result in more cancer cell growth.

**4. Change in the Nervous System and Brain Function**

Exposure to electromagnetic fields has been studied in connection with Alzheimer's disease, motor neuron disease and Parkinson's disease. These diseases all involve the death of specific neurons and may be classified as neurodegenerative diseases. There is evidence that high levels of amyloid beta are a risk factor for Alzheimer's disease, and exposure to ELF can increase this substance in the brain.

Melatonin helps protect the brain against damage leading to Alzheimer's disease, and exposure to ELF can reduce melatonin levels. Thus it is hypothesized that one of the body's main protections against developing Alzheimer's disease, melatonin is less available to the body when people areexposed to ELF.

Prolonged exposure to ELF fields could alter calcium ($Ca^{2+}$) levels in neurons and induce oxidative stress. It is also possible that prolonged exposure to ELF fields may stimulate neurons (particularly large motor neurons) into synchronous firing, leading to damage by the buildup of toxins.

Concern has also been raised that humans with epileptic disorders could be more susceptible to RF exposure. Low-level RF exposure may be a stressor based on similarities of neurological effects to other known stressors; low-level RF activates both endogenous opioids and other substances in the brain that function in a similar manner to psychoactive drug actions. Such effects in laboratory animals mimic the effects of drugs on the part of the brain that is involved in addiction.

Laboratory studies show that the nervous system of both humans and animals is sensitive to ELF and RF. Measurable changes in brain function and behavior occur at levels associated with new technologies including cell phone use. Exposing humans to cell phone radiation can change brainwave activity at levels as low as 0.1 watt per kilogram SAR (W/Kg) in comparison to the US allowable level of 1.6 W/Kg and the International Commission for Non-ionizing Radiation Protection (ICNIRP) allowable level of 2.0 W/Kg.

It can affect memory, learning and normal brainwave activity. ELF and RF exposures at low levels are able to change behavior in animals. Effects on brain function seem to depend in some cases on the mental load of the subject during exposure (the brain is less able to do two jobs well simultaneously when the same part of the brain is involved in both tasks).

Some studies show that cell phone exposure speeds up the brain's activity level; but, also that the efficiency and judgment of the brain are diminished at the same time.
One study reported that teenage drivers had slowed responses when driving and exposed to cell phone radiation, comparable to response times of elderly people. Faster thinking does not necessarily mean better quality thinking.

People who are chronically exposed to low-level wireless antenna emissions report symptoms such as problems in sleeping (insomnia), fatigue, headache, dizziness, grogginess, lack of concentration, memory problems, ringing in the ears (tinnitus), problems with balance and orientation, and difficulty in multi-tasking.

In children, exposures to cell phone radiation have resulted in changes in brain oscillatory activity during some memory tasks. Epidemiological studies can report harm to health only after decades of exposure, and where large effects can be seen across "average" populations, so these early warnings of possible harm should be taken seriously now by decision-makers.

**Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure**
**(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)**

| Power Density (Microwatts/centimeter2 - uW/cm2) | | Reference |
|---|---|---|
| As low as ($10^{-13}$) or 100 femtowatts/cm2 | Super-low intensity RFR effects at MW reasonant frequencies resulted in changes in genes; problems with chromatin conformation (DNA) | Belyaev, 1997 |
| 5 picowatts/cm2 ($10^{-12}$) | Changed growth rates in yeast cells | Grundler, 1992 |
| 0.1 nanowatt/cm2 ($10^{-10}$) or 100 picowatts/cm2 | Super-low intensity RFR effects at MW reasonant frequencies resulted in changes in genes; problems with chromatin condensation (DNA) intensities comparable to base stations | Belyaev, 1997 |
| 0.00034 uW/cm2 | Chronic exposure to mobile phone pulsed RF significantly reduced sperm count, | Behari, 2006 |
| 0.0005 uW/cm2 | RFR decreased cell proliferation at 960 MHz GSM 217 Hz for 30-min exposure | Velizarov, 1999 |
| 0.0006 - 0.0128 uW/cm2 | Fatigue, depressive tendency, sleeping disorders, concentration difficulties, cardio- vascular problems reported with exposure to GSM 900/1800 MHz cell phone signal at base station level exposures. | Oberfeld, 2004 |
| 0.003 - 0.02 uW/cm2 | In children and adolescents (8-17 yrs) short-term exposure caused headache, irritation, concentration difficulties in school. | Heinrich, 2010 |
| 0.003 to 0.05 uW/cm2 | In children and adolescents (8-17 yrs) short-term exposure caused conduct problems in school (behavioral problems) | Thomas, 2010 |
| 0.005 uW/cm2 | In adults (30-60 yrs) chronic exposure caused sleep disturbances, (but not significantly increased across the entire population) | Mohler, 2010 |
| 0.005 - 0.04 uW/cm2 | Adults exposed to short-term cell phone radiation reported headaches, concentration difficulties (differences not significant, but elevated) | Thomas, 2008 |
| 0.006 - 0.01 uW/cm2 | Chronic exposure to base station RF (whole-body) in humans showed increased stress hormones; dopamine levels substantially decreased; higher levels of adrenaline and nor-adrenaline; dose-response seen; produced chronic physiological stress in cells even after 1.5 years. | Buchner, 2012 |
| 0.01 - 0.11 uW/cm2 | RFR from cell towers caused fatigue, headaches, sleeping problems | Navarro, 2003 |

## 5. Effect on Genes

Cancer risk is related to DNA damage, which alters the genetic blueprint for growth and development. If DNA is damaged (the genes are damaged) there is a risk that these damaged cells will not die. Instead they will continue to reproduce themselves with damaged DNA, and this is one necessary precondition for cancer. Reduced DNA repair may also be an important part of this story.

The European research program (REFLEX) documented many changes in normal biological functioning in tests on DNA. The significance of these results is that such effects are directly related to the question of whether human health risks might occur, when these changes in genes and DNA happen. This large research effort produced information on EMFs effects from more than a dozen different researchers.

Some of the key findings included:

- "Gene mutations, cell proliferation and apoptosis are caused by or result in altered gene and protein expression profiles. The convergence of these events is required for the development of all chronic diseases."
- "Genotoxic effects and a modified expression of numerous genes and proteins after EMF exposure could be demonstrated with great certainty."
- "RF-EMF produced genotoxic effects in fibroblasts, HL-60 cells, granulosa cells of rats and neural progenitor cells derived from mouse embryonic stem cells."
- "Cells responded to RF exposure between SAR levels of 0.3 and 2 W/Kg with a significant increase in single- and double-strand DNA breaks and in micronuclei frequency."
- "In HL-60 cells an increase in intracellular generation of free radicals accompanying RF-EMF exposure could clearly be demonstrated."
- "The induced DNA damage was not based on thermal effects and arouses consideration about the environmental safety limits for ELF-EMF exposure."
- "The effects were clearly more pronounced in cells from older donors, which could point to an age-related decrease of DNA repair efficiency of ELF-EMF induced DNA strand breaks."

When the rate of damage to DNA exceeds the rate at which DNA can be repaired, there is the possibility of retaining mutations and initiating cancer. Studies on how ELF and RF may affect genes and DNA is important, because of the possible link to cancer. Laboratory studies have been conducted to see whether (and how) weak EMFs fields can affect how genes and proteins function.

Small changes in protein or gene expression might be able to alter cell physiology, and might be able to cause later effects on health and well-being.

**6. Effect on stress proteins**

In nearly every living organism, there is a special protection launched by cells when they are under attack from environmental toxins or adverse environmental conditions. This is called a stress response, and what are produced are stress proteins (a.k.a heat shock proteins). Plants, animals and bacteria all produce stress proteins to survive environmental stress like high temperatures, lack of oxygen, heavy metal poisoning, and oxidative stress (a cause of premature aging).
We can now add ELF and RF exposures to this list of environmental stressors that cause a physiological stress response.

An additional concern is that if the stress goes on too long, the protective effect is diminished. There is a reduced response if the stress goes on too long, and the protective effect is reduced. This means the cell is less protected against damage, and it is why prolonged or chronic exposures may be quite harmful, even at very low intensities.

The biochemical pathway that is activated is the same for ELF and for RF exposures, and it is non-thermal (does not require heating or induced electrical currents, and thus the safety standards based on protection from heating are irrelevant and not protective). ELF exposure levels of only 5 to 10 mG have been shown to activate the stress response genes. The specific absorption rate or SAR is not the appropriate measure of biological threshold or dose, and should not be used as the basis for a safety standard, since SAR only regulates against thermal damage.

**7. Plausible Biological Mechanisms**

Plausible biological mechanisms are already identified that can reasonably account for most biological effects reported for exposure to RF and ELF at low-intensity levels (oxidative stress and DNA damage from free radicals leading to genotoxicity; molecular mechanisms at very low energies are plausible links to disease, e.g., the effect on electron transfer rates linked to oxidative damage, DNA activation linked to abnormal biosynthesis and mutation).

It is also important to remember that traditional public health and epidemiological determinations do not require a proven mechanism before inferring a causal link between EMFs exposure and disease. Many times, proof of mechanism is not known before wise public health responses are implemented.

# Precautionary Measures you can take

Since the problem of EMR radiations is more prevalent on a larger scale, we can't really do anything about it. But the general masses can take some precautionary measures to curb the high level of radiations around them.

- **Turn off mobile Data**: Wi-Fi & Bluetooth services when not actively using your smart mobile device to reduce background data transmissions. Also occasionally consider using only SMS! It's also worth noting that when GSM signal reception is low, cell phones typically increase in radiation levels to compensate. In such cases, keep your cell phone at a reasonable distance from your body and use a headset or speakerphone.

- Whenever possible, **use speaker mode** and texting as these can help to increase distance between your body and the cellphone thus minimizing radiation. Putting the cell phone against your ear, in your shirt pocket, in your
  - pants pocket, or any other place on your body, should be avoided.

- **Using a wired internet** is always recommended as a safety measure. However, we need to appreciate that the world is becoming more "connected on the move, anytime anywhere" and the best we can do, is to take precautionary measures that minimize radiation. It's therefore best to use wired internet if your office is fitted with fixed data points (wired internet also offers a better/stable connection than wireless and reduces the risk of data breach). However, if all you have in your office is wireless internet, make sure you are not seated right next to the wireless router!

- **Run your computer off of battery** as opposed to using it while charging. Also do not put your laptop directly on your lap, because of potential dangers from the magnetic fields, intermediate radio-frequencies, electric fields (if plugged in), and wireless radiation (if using wireless internet).

- Is your office located in a server room with racks and high-performance servers? Then you might be sitting in the wrong place! Server racks are generally designed with anti-radiation glass and the metallic parts with anti-radiation coating and that is why you need to keep them locked with a key).

If the server racks you are sitting next to are open, then you are exposing yourself to high levels of radiation. DICTS main server room, is separated from our offices with anti-radiation glass. No one sits and works from the server room.

- **Replace CFL bulbs with alternatives**. The frequencies emitted by CFL bulbs may interfere with the health. It is advicable to switch to alternative forms such as bulbs, incandescent bulbs etc.

- **Reduce electricity exposure near sleeping areas** - if possible, plug in lamps and alarm clocks away from sleeping areas, since electricity may interfere with melatonin production, which is needed for restful sleep.

- **Building Thick walls of houses –** It has been found that people living in urban areas have still been able to protect themselves from EMR by living in houses with thick walls. These walls shed the intensity of the EMF which may protect us but may lead to poor connectivity inside the house.

- **Using Thick curtains –** Thick curtains are more efficient than thick walls as they absorb unnecessary EMF while allowing some to pass providing better connectivity as well as some protection.

# Current Guidelines on the EMF Radiation Values

- ICNIRP issues guidelines on the basis of current scientific knowledge. Most countries draw on these international guidelines for their own national standards.
- Standards for low frequency electromagnetic fields ensure that induced electric currents are below the normal level of background currents within the body. Standards for radiofrequency and microwaves prevent health effects caused by localized or whole-body heating.
- Guidelines do not protect against potential interference with electromedical devices.
- Maximum exposure levels in everyday life are typically far below guideline limits.
- Due to a large safety factor, exposure above the guideline limits is not necessarily harmful to health. Furthermore time-averaging for high frequency fields and the assumption of maximum coupling for low frequency fields introduce an additional safety margin.

These are the maximum level of admissible public exposure, as per the guidelines set by WHO ~

| | **Power frequency** | | **Mobile phone base station frequency** | | **Microwave oven frequency** |
|---|---|---|---|---|---|
| **Frequency** | 50 Hz | 50 Hz | 900 MHz | 1.8 GHz | 2.45 GHz |
| | **Electric field (V/m)** | **Magnetic field (μT)** | **Power density (W/m2)** | **Power density (W/m2)** | **Power density (W/m2)** |
| **Public exposure limits** | 5 000 | 100 | 4.5 | 9 | 10 |
| **Occupational exposure limits** | 10 000 | 500 | 22.5 | 45 | |

These are the maximum admissible exposure radiations at your house

| **Source** | **Typical maximum public exposure** | |
|---|---|---|
| | **Electric field (V/m)** | **Magnetic flux density (μT)** |
| **Natural fields** | 200 | 70 (Earth's magnetic field) |
| **Mains power**<br>**(in homes not close to power lines)** | 100 | 0.2 |
| **Mains power**<br>**(beneath large power lines)** | 10 000 | 20 |
| **Electric trains and trams** | 300 | 50 |
| **TV and computer screens**<br>**(at operator position)** | 10 | 0.7 |

| | **Typical maximum public exposure (W/m2)** |
|---|---|
| **TV and radio transmitters** | 0.1 |
| **Mobile phone base stations** | 0.1 |
| **Radars** | 0.2 |
| **Microwave ovens** | 0.5 |

# What precautions are being followed?

With more and more research data available, it has become increasingly unlikely that exposure to electromagnetic fields constitutes a serious health hazard, nevertheless, some uncertainty remains. The original scientific discussion about the interpretation of controversial results has shifted to become a societal as well as political issue.

The public debate over electromagnetic fields focuses on the potential detriments of electromagnetic fields but often ignores the benefits associated with electromagnetic field technology. Without electricity, society would come to a standstill. Similarly, broadcasting and telecommunications have become a simple fact of modern life. An analysis of the balance between cost and potential hazards is essential.

## 1. Protection of public health

International guidelines and national safety standards for electromagnetic fields are developed on the basis of the current scientific knowledge to ensure that the fields humans encounter are not harmful to health. To compensate uncertainties in knowledge (due, for example, to experimental errors, extrapolation from animals to humans, or statistical uncertainty), large safety factors are incorporated into the exposure limits. The guidelines are regularly reviewed and updated if necessary. It has been suggested that taking additional precautions to cope with remaining uncertainties may be a useful policy to adopt while science improves knowledge on health consequences. However, the type and extent of the cautionary policy chosen critically depends on the strength of evidence for a health risk and the scale and nature of the potential consequences. The cautionary response should be proportional to the potential risk. For more information, see the WHO Backgrounder on Cautionary Policies.

Several policies promoting caution have been developed to address concerns about public, occupational and environmental health and safety issues connected with chemical and physical agents.

## 2. What should be done while research continues?

One of the objectives of the International EMF Project is to help national authorities weigh the benefits of using electromagnetic field technologies against the possibility that a health risk might be discovered. Furthermore, the WHO will issue recommendations on protective measures, if they may be needed. It will take some years for the required research to be completed, evaluated and published. In the meantime, the World Health Organization has issued a series of recommendations:

- Strict adherence to existing national or international safety standards: such standards, based on current knowledge, are developed to protect everyone in the population with a large safety factor.
- Simple protective measures: barriers around strong electromagnetic field sources help preclude unauthorized access to areas where exposure limits may be exceeded.
- Consultation with local authorities and the public in siting new power lines or mobile phone base stations: siting decisions are often required to take into account aesthetics and public sensitivities. Open communication during the planning stages can help create public understanding and greater acceptance of a new facility.
- Communication: an effective system of health information and communication among scientists, governments, industry and the public can help raise general awareness of programs dealing with exposure to electromagnetic fields and reduce any mistrust and fears.

## 3. Different types of studies are needed

A mix of studies in different research areas is essential for the evaluation of a potential adverse health effect of electromagnetic fields. Different types of studies investigate distinct aspects of the problem. Laboratory studies on cells aim to elucidate the fundamental underlying mechanisms that link electromagnetic field exposure to biological effects. They try to identify mechanisms based on molecular or cellular changes that are brought about by the electromagnetic field - such a change would provide clues to how a physical force is converted into a biological action within the body. In these studies, single cells or tissues are removed from their normal living environment which may inactivate possible compensation mechanisms.

Another type of study, involving animals, is more closely related to real life situations. These studies provide evidence that is more directly relevant to establishing safe exposure levels in humans and often employ several different field levels to investigate dose-response relationships.

Epidemiological studies or human health studies are another direct source of information on long-term effects of exposure. These studies investigate the cause and distribution of diseases in real life situations, in communities and occupational groups. Researchers try to establish if there is a statistical association between exposure to electromagnetic fields and the incidence of a specific disease or adverse health effect. However, epidemiological studies are costly. More importantly, they involve measurements on very complex human populations and are difficult to control sufficiently well to detect small effects. For these reasons, scientists evaluate all relevant evidence when deciding about potential health hazards, including epidemiology, animal, and cellular studies.

# CONCLUSION

Little of us are aware about the discussed harmful side-effects of EMF Radiation around us and also the protective measures which are neglected.

We hope that this detailed report was successful in raising awareness and will guide people to be more careful around high exposures of EMF Radiation.

This Report provided a detailed research on ~

- Identification of sources of EMF Radiation around us
- Effect of these radiations to nature and our body
- Side-effects and diseases caused by long-term exposure to them
- Precautionary measures
- Safety Regulations on appliances.

Also, the purpose of this report was to catch the attention of Educational Boards towards the dangerous health effects caused among students during the time of pandemic when we were exposed to heavy amount of EMF Radiation while using the internet and laptops and other devices almost all-day long for the past 6 months. This report focused on how even little amounts of EMF exposure could attack the immune system of an adolescent making him/her vulnerable to the COVID-19 virus. The last few months have been a lot hard for students especially, as almost all of us had severe headaches at a point of time when sitting in an atmosphere pf heavy exposure to EMF.

We hope that this Project Report finds its way to the higher authorities of our educational system and they come up with some better method for evaluation of our studies or reduce time for EMF exposure.

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