Chapter I

INTRODUCTION

There are number of devices which have become essential part of our life. Modern communications devices, medical devices, medical equipments, and electrical devices are the commonly used devices. It is not possible to imagine life without these equipments. The working of these devices is based on principles of electricity and magnetism. Many devices employ electromagnetic radiation for their functioning. All living things on earth ultimately depend on the electromagnetic radiation received from the Sun.

The sun is giving us energy continuously. We are just using various forms of the solar energy. Wind energy also depends upon solar radiation. Solar energy is utilized by plants and animal to prepare their foods. Hence it is always said that “it is very difficult to imagine universe without sun”.

The conversions of solar energy in to food in the process of photosynthesis by plant, is the basic step in the food chain depends on electromagnetic radiation. The process begins with absorption of solar energy by photosynthetic pigments like chlorophyll a, chlorophyll b, caretonoid etc. These pigments absorb photon and initiate food chain. The green plants are receptive to the solar radiation as they contain chlorophylls in large amount. This light in form of radiation is absorbed by chlorophyll pigment in the leaves and produces foodstuff necessary for growth of plant. The end product of photosynthesis is sugar [1].

The eyes of many animals, including those of humans, are adapted to be sensitive sun light. Human beings have rod and cones for seeing the light. Rods are responsible observing images in dim light and become active during night. The cones are responsible colour vision.
Solar spectrum comprises visible portion of wide range of frequencies. Basically, all the energy reservoirs in the universe are stored forms of the energy received from the Sun since millions of years. Sun is the basic source of radiation present in the universe.

Electromagnetic radiation is contains various energy in form of waves traversing through space with the velocity of $3 \times 10^8$ m/s. It includes radio waves, microwaves, visible, ultraviolet rays and gamma rays. Frequency of wave differentiates these classes of radiation [2].

Our life is dependable on artificial electromagnetic radiation (EMR) also. Examples of the applications of electromagnetic radiation include:

1. Warming food is done by microwave ovens which is an integral part of our kitchen.
2. Aircraft’s are guided by radar waves. In radar radio waves are generated by transmitters. They are reflected from aircraft and again received by receiver in radar system. By knowing the time the distance between target and observer can be calculated.
3. Broadcasting of all radio stations and receiving signals TV stations.
4. Automatic self-focusing cameras
5. Mobile phone communications.
6. Radiation emitted by cell tower.
8. Radiation generated in imaging techniques such as x-ray radiography, computer tomography etc.
9. Radiation emitted by stray light
10. Radiation due to powerline which has entered in every corner of house.
11. House is filled with number of electrical appliances like refrigerator, hot plate, heater etc.


13. Electrical high voltage power lines near schools, colleges and societies with transformer.

14. Radiation emitted in natural disasters

15. Radiation due to underground waters and geopathic zones.

16. Use of ultraviolet techniques in medicine

Ultraviolet radiation cannot be seen by eye but its effect can be harmful to life. Same is the case of X-rays, which are play important in diagnosis and treatment in medicine. X-rays allow physicians to examine the inner organs of the body and any disorder in the functioning can be interpreted. The exposure of X-ray is kept to a minimum to avoid hazards of this invisible and high energy radiation.

In the present topic, historical background of electromagnetic waves, electromagnetic spectrum, types of radiation, problem on hand, objective, importance and scope of the study is discussed.

1.1 HISTORICAL PERSPECTIVE OF ELECTROMAGNETIC WAVES

During ancient days people were worshiping the God sun being a huge source of energy. In Vedas and Puranas, sun devata was supposed to have big power and he offers the power to the people worshipping him. The process of surya dan and surya namskar originated from that time. Even during solar eclipse people used to donate something to others so that the sun is free from eclipse. People were expecting that by doing this the sun will remove all the darkness. Later on people called this invisible power as electromagnetic energy.
In the beginning of the nineteenth century, the experimentation of Oersted was a remarkable event in electricity and magnetism. He showed that whenever the current carrying wire produces magnetic field. He passed electrical current through one coil and observed effect in the nearby coil kept. Whenever a magnetic needle was kept in the near to nearby coil, the needle showed deflection. The rate of magnetic flux was more at the time of switching on and of the current. The Orested experiments indicated that whenever there was change in electric flux, magnetic field was produced. Reverse was also found to be true.

Ampere also proved that moving charges create a magnetic field. Later on Faraday and Henry confirmed that a moving magnet induces an electric current. Michael Faraday showed that a varying magnetic field induces an electromotive force in the coil. Thus, current passing through a conducting wire produces magnetic field. The change in magnetic flux in the coil produces electromagnetic force indicating that electricity is linked with magnetism. This principle is widely applicable in case of transformers used commonly in electronics.

Afterwards, Maxwell devised a theory that connected the fundamental phenomena of electricity and magnetism. Maxwell concluded his paper “On the Physical Lines of Force (1861–1862) by saying that electricity may be disseminated through the space with properties identical with those of light” [3]. In the year 1864, he established the electromagnetic theory. According to Maxwell, “light is an electromagnetic disturbance in the form of waves”. Maxwell predicted the properties of electromagnetic waves (EM). These properties are:

1. All electromagnetic waves pass through the vacuum.
2. The velocity of electromagnetic waves is \(3.00 \times 10^8\) m/s
3. Electromagnetic radiation obeys the universal wave equation.
4. Electromagnetic waves are produced whenever electric charges are accelerated. This is because moving charges with high speed loose energy which is carried away as electromagnetic waves.
5. If an electric charge is accelerated periodically, the frequency of the electromagnetic waves equals the frequency of the oscillations of the charge.

6. Electromagnetic waves demonstrate phenomenon like interference, diffraction, polarization, refraction, etc.

7. Its intensity of radiation is proportional to the square of the amplitude of the electric (or magnetic) field and to the square of the frequency

First man-made electromagnetic waves were produced by Heinrich Hertz, a German scientist in 1887. He showed that EM waves exist and behave exactly as Maxwell’s prediction. Afterward, Hertz made a second most important investigation by producing electromagnetic radiation of radio frequencies. Hertz experiment regarding production of electromagnetic radiation was milestone in the history of electromagnetic radiation.

Hertz proved that these waves have the properties like reflection, diffraction, refraction, and interference as that of light. He showed that such electromagnetic waves can be polarized and have two vectors.

When either an electric or magnetic field is varying with time, a field of other kind is induced in neighboring area of space. Maxwell believed that such electromagnetic disturbances consist of time changing electric and magnetic fields. These fields are propagated through space from one region to another, even after there is no matter in the region. Such disturbance, if it is present, will have the properties of waves.

Such waves were referred as electromagnetic waves. At the same time, he Maxwell discovered that the basic principles of electricity and magnetism, called as Maxwell’s equation. These equations are basic equation in electrodynamics. These equations are applicable in dynamics theory.

The electromagnetic waves that make electromagnetic radiation can be imagined as a self-propagating transverse oscillating wave. The wave is made of electric and magnetic fields as indicated in Fig. 1.1.
The figure indicates an electromagnetic wave travelling from one direction to other. In the figure E (electric field) is in an upright plane and the magnetic field in a perpendicular straight plane to E. These two fields of electromagnetic radiation are always in phase with each other with a constant ratio of electric to magnetic field intensity. Such wave exists in radio and television communication, x ray and many kind of radiation.

Hertz’s inventive experiments gave idea for constructing transmitters and, antennas, making cables for radio-frequency electromagnetic radiation. The Maxwell–Hertz hypothesis of electromagnetic radiation was known as Maxwell’s theory.

![Electromagnetic wave](image.png)

**Fig 1.1: Electromagnetic wave**

According to Maxwell’s theory there was no medium through which the electromagnetic waves propagate. Electromagnetic radiation travels through space by itself. Hertz’s formulation of Maxwell’s theory made it clear that no medium of any sort was needed for the propagation of electromagnetic radiation.
1.2 ELECTROMAGNETIC SPECTRUM:

Electromagnetic radiation is divided into various types of waves regions depending on wavelength. The sequential collection of electromagnetic waves according to their wavelengths in variety of distinctive sets having different properties is an electromagnetic spectrum. In the spectrum, the increase in wavelength is associated with decrease in frequency and vice versa.

Despite enormous variation in their uses and methods of production, all these waves travel with same velocity. Various regions of electromagnetic radiation as per increasing energy are listed below.

1. Radio waves
2. Microwaves
3. Radar waves
4. Infrared waves
5. Visible light
6. Ultraviolet light
7. X-rays
8. Gamma rays
9. Cosmic rays

The various waves in the electromagnetic spectrum are shown in Fig.1.2.
The details about each wave are described below.

**Radio waves**

Radio waves are the waves of lowest frequency and hence lowest energy. Radio waves have long wavelengths ranging from few centimeters to few hundred kilometers. These waves are used in broadcasting and transmission of radio and television signals. Mobile phones use radio waves to transmit voice communication in ultra high frequency region. The distance traversed by the signal during one period varies from a few meters up to thousands of meters. The transmitting antennas are of comparatively large size.
Radio waves are also employed to generate very low frequency waves for communication purpose in underwater submarines. They have highest wavelengths in the electromagnetic spectrum. They are created by lightning and several astronomical objects such as stars and galaxies. Radio waves are commonly used in

- Internet connectivity.
- Satellite communication.
- Broadcast antenna, radar devices,
- Satellites,
- Cell phones and cell phone towers
- Pagers,
- Telephones,
- Television
- Remote controls are the major sources of radio waves.

**Microwaves and Radar waves**

These waves are produced by electronic circuits with transmitter and receiver antennas. Microwaves are produced by klystron, magnetron and gun diode. They are normally around one meter or less in size. Microwaves have frequencies in range $5 \times 10^9$ Hz to $1 \times 10^{12}$ Hz.

Microwaves can be used

- To transmit signals through the space.
- To keep the food warmth in microwave oven.
- They are also employed in remote sensing.
• They are used for broadcasting the information because the energy can pass through substances such as clouds.
• Short microwaves are sometimes used in Doppler radars to forecast weather conditions

**Infrared waves**

Infrared waves are of high frequency. These are usually formed by oscillating electric charges in atoms and molecules. Vibrational or rotational motions of the molecules can produce such waves and are related to the temperature of the material. At higher temperatures there are more rapid oscillations and therefore produce waves of higher frequency.

Infrared rays have wavelength ranging from $10^{-6}$ meter to $8 \times 10^{-4}$ meter. When these rays fall on any object, it gets heated. They are strongly absorbed by glass. They can penetrate through thick column of fog and mist. Sources of infrared rays are all the hot bodies.

**Visible light**

The visible region of the spectrum is sensed by photosensitive pigments named as cones in the human eye. Atoms and molecules vibrate and oscillate and produce light in the visible range. In addition, it can be produced when electrons in atoms are reorganized into different energy levels. It is well-known that every electron in atoms has definite particular energy. When it makes a transition from one energy level to another, it may emit light in form of electromagnetic radiation. Visible light have wavelength ranging from $3.8 \times 10^{-7}$ m to $7.4 \times 10^{-7}$m.

Visible light contains various colours of light. Different parts of visible spectrum evoke in human the sensation of different colours. The colours and their wavelengths are shown in Table 1.1.
Table 1.1: Different colours and wavelength in visible spectrum.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Wavelength in nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violet</td>
<td>380-435</td>
</tr>
<tr>
<td>Blue</td>
<td>435-500</td>
</tr>
<tr>
<td>Cyan</td>
<td>500-520</td>
</tr>
<tr>
<td>Green</td>
<td>520-565</td>
</tr>
<tr>
<td>Yellow</td>
<td>565-590</td>
</tr>
<tr>
<td>Orange</td>
<td>590-625</td>
</tr>
<tr>
<td>Red</td>
<td>625-740</td>
</tr>
</tbody>
</table>

The sources of visible radiation include, rays coming from sun and light bulb.

**Ultraviolet light**

The electronic transition in atoms is also responsible for creation of ultraviolet. They are produced by material having very high temperature such as sun and electric arc. This is because at high temperature there are vigorous vibrations of atoms. Ultraviolet rays have short wavelength ranging nearly $10^{-8}$ m to $10^{-7}$ m. Ultraviolet rays cannot pass through glass. But they pass through material like quartz, fluorite, rock salt etc. These waves have higher energy than that of visible region.
Ultraviolet light causes photoelectric effect. When ultraviolet rays fall on photosensitive material, these radiations are absorbed by the material. There is interaction between photons of incident light and electrons within the metal. The kinetic energy of photon is transferred to electron inside the material. If the given energy is greater than work function, at particular frequency called as threshold frequency, photoelectrons are emitted from the material.

Ultra violet light cannot be observed by human eye but can be sensed by skin. There is fluid named as melanin below skin that plays important role in and absorption of the radiation and skin colour. It also causes skin cancer when irradiated continuously and damage DNA.

Many insects and birds can see ultraviolet waves that human can not. Many birds including budgies, parrots and peacocks have ultrasonic patterns on their bodies that make them even more vivid to each other that they appears to us.

**X-rays**

X-ray invention by Rontgen was the important discovery of 20th century. X-rays are produced in laboratory by Coolidge tube when cathode rays with high speed fall on target material. The target material has high melting point and surrounded by cooling arrangement. During collision in between cathode rays and targeting material, high-energy electronic transitions takes place in heavier atoms. These atoms possess larger numbers of electrons. Some of these electrons have very high energies. These electrons are knocked out from metals and emerged out in form of X-ray.

In addition, X-rays can be produced by the fast deceleration of high-energy electrons. Deceleration of electron occurs when they are suddenly brought to a stop by hitting metal target like tungsten. These are high energy electromagnetic waves having very short wavelength ranging from $10^{-11}$ m to $10^{-8}$ m.

X rays have high penetrating power and can ionize through gas in which they pass. When X-rays are incident on metal surface, electrons are emitted from these surfaces. This effect is called as photoelectric effect.
Medical X-rays are of 1-10 Å wavelengths. X rays are used in medicine for diagnosis and therapy. They are used in angiography technique for observing blocks in arteries. Other advanced imaging techniques like computer tomography also employ x-ray in imaging.

X-ray imaging is one of most common method used in detecting invisible material in body and to scan the bags on airport and other important places. Naturally, X-rays are emitted by sun, neutron stars and binary star system.

**Gamma rays**

Gamma rays have high frequencies ranging from $3 \times 10^{18}$ Hz to $5 \times 10^{20}$ Hz. They have wavelength ranging nearly from $10^{-12}$ m to $10^{-10}$ m. They have shorter wavelength as compares with x-ray. They are also created in the very small nucleus of the atom. Due to extremely rapid oscillations and frequency they have very high energy. Terrestrial thunderstorms, pulsars, quasars and active galaxies also produce gamma rays.

These rays are highly penetrating. They kill living cell on which they are incident. They are commonly used in radiological treatment in hospital as nuclear medicine. Cobalt CO$^{60}$ is one of the common radioactive sources used in cancer treatment. Other uses of gamma rays include

- measurement of soil density
- packaging of food and drugs
- sterilizing medical equipments and
- Pasteurizing foods and spices.
- They are also employed in geophysics research.

**Cosmic rays**

These rays are of very high frequency in the electromagnetic spectrum. They are created from the sources existing in outside the solar system. The exact nature of cosmic rays is still not completely understood by scientists. Numbers of investigators are working in this direction.
1.3 IONIZING RADIATION AND NON IONIZING RADIATION:

Electromagnetic radiations can be divided into two types. These types are named as

- Ionizing radiation and
- Non-ionizing radiation.

The basis of this classification is capability of atoms to ionize and break the covalent bonds. If given electromagnetic radiation has sufficient energy to remove the electrons in the outermost orbit of atom, thereby creating charged particles or ions, it is called as ionizing radiation.

All other forms are of electromagnetic radiation are known as non-ionizing. The power of non ionizing radiation is not sufficient to start the ionization process. But its effects of non ionizing radiations when ever these radiations are irradiated for longer periods are considerable.

Ionizing radiation has enough energy to streak atoms and to knock out the electrons from the material. The electromagnetic energy converts the molecules into ions. X-rays and gamma rays commonly used in the medicine lie in this category of the radiation.

X-rays, gamma rays and short wavelength end of electromagnetic spectrum are ionizing radiations. It includes alpha, beta particles and neutron. These particles may damage the cell. We are exposed to such ionizing radiation from inherent sources or natural background radiation continuously. Ionizing and non-ionizing radiation are shown in Fig 1.3.
Ionizing radiations can be artificially created by particle accelerators, nuclear reactor and during production of high energy X-ray. Natural sources of ionizing radiations are sun, lightning and supernova outburst. As these rays are invisible, detection they are detected by Geiger counters.

These radiations are used in medicine for treatment purpose. Low exposure of these radiations is used to sterilize and clean medical equipments and irradiating food for preservation also. When living tissue is exposed to such radiation it can damage the cell. Over exposure to ionic radiation can cause transformation in the cell, induction of cancer and even death also.
Non-ionizing radiation:

In case of non-ionizing radiation the energy available from mainly common sources is insufficient to produce any type of harm to individual tissue. It is reported by researchers that high power concentrations, such as high-voltage power lines or high-power, transmitting antennas could have enduring health effects if they are irradiated for longer time [4].

The effects of electromagnetic radiation on human body depend on the frequency and power of the radiation. For lower wavelength frequency will be higher and consequently energy of radiation will be higher. For waves in the range of radio waves has less energy as compared with that of to visible light having low-frequency (or higher wavelength). In case of non ionizing radiations, the effects are due to radiation power only.

When the radiation is absorbed by the cell within body, heat is produced in the body. Hence, these effects are referred as thermal effects. In the thermal effects, the radiation frequency is considerable because this energy is responsible for its dissemination into the organism.

For example microwaves penetration through the object is superior to infrared radiation. It was anticipated that field due to lower frequency is very feeble to cause observable heating. However if radiation is for longer time it may cause adverse effects. The waves in these categories are direct current having 0 frequencies to waves above frequencies 300 GHz.

These non-ionizing radiations with its types and the frequencies in which they occur are shown in Table 1.2.
Table 1.2: Non ionizing radiation

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Type</th>
<th>Frequency range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electromagnetic fields from direct current (static)</td>
<td>0 Hz</td>
</tr>
<tr>
<td>2</td>
<td>Waves from electric power (Low-frequency)</td>
<td>50 -60 Hz</td>
</tr>
<tr>
<td>3</td>
<td>Extremely Low Frequency (ELF) and Very Low Frequency (VLF) fields</td>
<td>Up to 30 KHz</td>
</tr>
<tr>
<td>4</td>
<td>Radio Frequencies (RF) including Low Frequency (LF), Medium Frequency (MF), High Frequency (HF), Very High Frequency (VHF), Ultra High Frequency (UHF) and Microwave (MW) and Millimeter wave</td>
<td>From 30 kHz to 300 GHz.</td>
</tr>
<tr>
<td>5</td>
<td>Infrared (IR) light, Visible light and Ultraviolet (UV) light</td>
<td>Above 300 GHz</td>
</tr>
</tbody>
</table>

The continuous exposure to electromagnetic fields due to sources like power line appliances and radiofrequency radiation has been linked with many adverse health effects [5, 6].

Childhood and adult leukemia, adult brain tumors and increased risk of the neurodegenerative diseases and alzheimer are the most reported sever health consequence in connection with extremely low frequency and/or radiofrequency radiation.
Danger of electromagnetic radiation

There are various types of dangers due to electromagnetic radiations.

These are:

- Fire danger
- Biological danger
- Electrical danger
- DNA disintegration

The risk due to fire is because of electric arcs. Whenever the energy of EMR is high there is probability of spark. When the sparks are produced they ignite the ignitable material. This will cause explosion. There are cases of such outburst in the vicinity of likely to explode areas.

The most discussed and debatable is dielectric heating due to electromagnetic radiations. When a person touches antenna during high power transmission, there is possibility of severe burn. Same burn can be experienced by person using microwave oven. The burning depends on frequency of radiation and frequency of radiation. Such exposure can be measured in terms of specific absorption ratio.

Electrical dangers occur when strong EMR can induce current. If current is high it can deliver electric shocks. In such situation there is possibility of electrical system to be damaged. There are cases of explosion of power distribution system and events of blackouts.

Even an exposure of radiation having frequency of 50 Hz increases the DNA fragmentation. DNA disintegration can cause serious problem in health condition even the person is healthy and normal.

We are facing problems of air pollution, water pollution, land pollution and noise pollution. In addition to these one has to consider pollution generated due to
electromagnetic radiation also. There are some safety ways to reduce the new “electromagnetic pollution”.

The effects of electromagnetic pollution can be reduced by considering these radiations in high frequency and low frequencies regions.

To reduce effects of low frequency field:

1. One should sleep in minimum lighted room or at least eyes must be covered with cloths.
2. All the electrical points must be switched off.
3. A person handling electrical appliances should keep himself few meters away from devices.
4. TV should be seen from longer possible distances.
5. Computers has stronger radiation than TV, so constant monitor observation should be avoided or break in seeing should be taken after every 15 minutes

High frequency radiations are due to especially cellular phones. These radiation area also produced by huge structure, mobile towers situated to make availability of proper network coverage. The high frequency radiation can cause

1. An electromagnetic field produces heat. Heat produced can cause biological heating effects.
2. Specific absorption of high frequency radiation is high and can cause tissue heating.

The ways to minimize the radiations are discussed in the succeeding topics.
1.4 PROBLEM ON HAND:

According to recently published BioInitiative report, there were abundant information of increasing enlargement in danger and warnings about cancer especially of breast cancer in women. These reports also indicated that children and youngster are at the higher risk site. There are also reports showing significant effects on genotoxicity and discharge of the blood–brain barrier.

Similarly, changes in heart rate and some cardiovascular effects with change in strength of immunity including augmented sensitive and inflammatory responses have been reported. In some studies, people living in proximity of very low intensity RF areas like WI-FI and cell tower level areas are victims of sleep disturbance. Temporary effects on cognition, remembrance and learning, misconduct, response time, awareness and attentiveness and distorted brain wave activity were also observed by scientist [7]. The problem in hand is of effects of electromagnetic radiation on human health. The biological consequences of electromagnetic radiation are subject of present study. The sources which cause the health effects and their impact on cardiovascular system are main theme of the investigation. These sources are classified in three categories.

These categories are as discussed below.

Problems due to radiation generated by communication devices or radio frequency sources

Presently, communication devices such as wireless phones, mobile phones and electrical appliances are commonly employed in daily life. Younger generation is more and more addicted to continuous use mobile phones by using it for continuous talk, hearing music, downloading and playing various These students have all the information about new applications of mobile phones. Youngsters suppose mobile phone as a status symbol without knowing ill effects of it.
These devices become necessary part of our life. Large numbers of these devices produce electromagnetic radiations continuously. These electromagnetic or radiofrequency (RF) radiations are widely exploited in the communication devices.

The first demonstration of mobile handset phone was successfully demonstrated by John F. Mitchell and Dr Martin Cooper of Motorola in 1973. Later on in 1983 with some modifications Dyna TAC 8000x was made available in the market.

Presently, at global level there are more than 6.57 billion mobile phone subscribers. In India, the cellular phone service was initiated on 15 August 1995 in Delhi on the non-commercial base. During last 19 years, the scenario had been completely changed. There has been an exponential growth of mobile telephony in India and all over the globe.

As per data available from Telephone Regulatory Authority of India, on 31 March 2014, there are 904.51 millions of people using mobile phones all over India. The data indicates that 78% of India’s population is using mobile phones. To complete the demand, 20 companies provide mobile telephone service in India and about 100 companies are manufacturing the mobile phones all over the globe. The majority sellers are Samsung, Nokia, Sony, Motorola, Blackberry and so many others also. The number of mobile manufacturing companies with various attractive features are continuously increasing every day.

To provide better coverage for mobile signals or connectivity more than 70 millions towers are erected in India. During tower erection the consideration of its health hazards is a question of debate. No the companies think about health effect because they have to do the business. Nor the customers or people staying near about its zone think because they get money for the tower establishment to society or that particular area.

With this tremendous increase in mobile users and mobile companies, many local and non government and government industries are approaching in the ever increasing and financially rewarding region. It is said in these industries that everybody has a share in the big cake.
The intensity of electromagnetic radiation from communication devices is increasing endlessly. It is known as an invisible and dangerous pollution that may affect life in numerous ways. Base transmission towers give out electromagnetic radiation constantly which has unfavorable impacts on human as well as on wildlife. On the other hand essential regulatory policies were not implemented with the mammoth growth of mobile telephony.

According to International Agency of world health organization RF-EMF from cell phones can be designated as “possible human carcinogen” Class 2B Cancer [8]. Mobile tower radiations can cause both thermal and non-thermal injuries. The damage may be due to heating at tissue level showing denaturation of proteins, disorder of molecule, changes in chemical reaction in the cell, heat shock proteins and even modifications in the enzyme in the cells.

Intensity of radiofrequency (RF) and exposure period of non-ionizing radiation causes harm to the biosystem and ecosystems also. The information of intensity and exposure period is useful to develop strategies for improvement and provides guidelines to use the technology. It will allow us for the appropriate use of wireless technologies to have its massive benefits. In case of the animal species, impact of RF radiation on birds and bees are relatively more noticeable.

Various studies have shown ill-effects of radio-frequency electromagnetic field on bees, fruit flies, frogs, birds, bats and humans, but the long-term studies of such exposures are inconclusive, rare and almost non-existent in India. Short-term studies on the impacts of radio frequency electromagnetic field on frogs, honey bees, house sparrows, bats and even humans are alarming.

Honey bees emerge to be very sensitive to electromagnetic field. It had been noticed that honey bee colony are reducing day by day. If their behavioral responses are scientifically recorded, it could used as an indicator of EMF pollution. Einstein said that, “If the bee disappears from the surface of the earth, man would have no more than four years to live.”
The radiation of non-ionizing type is believed not much harmful like the ionizing radiation, but the over and long term exposure of it may be unsafe and detrimental. The radiation due to such electro-magnetic fields (EMF) is called ‘electro-smog’. The EMR are not readily sensed by any human organ and hence can be easily noticeable. However, radiation effects on human body are expected to be dangerous and never-ending at all.

An effort is needed to prepare a survey of biological effects due to RF frequency. The following points are needed to be considered for better conclusion.

a. Duration of mobile phone use  
b. Number of devices used at a time  
c. Average calls received and dialed per day  
d. Position of keeping mobile phone  
e. Information about use of such devices by children  
f. Information about hypersensitive people  
g. Information about mobile tower in vicinity of crowded area.  
h. Radiation effects due to mobile towers.  
i. Preventive measures to be taken to reduce the radio frequency radiation.  
j. Biological effects such as 
   Fatigue, dizziness, loss of attention, memory loss,  
   Disturbance in sleep, mental weakness  
   And other associated health problems
Problems due to radiation generated due to electrical power lines

The powerline brings electricity from power generation centre to our house. In this way it plays important role in transmission from production centre to users. For this purpose high voltage power lines with towers are used. Houses are not constructed near such powerline. The electric towers also occupy the land near to it. The electric fields generated due to power line causes many problems.

It is easier to guard the electric field generated by powerline but the magnetic field produced by the powerline can’t be safe guarded. The problem of adverse effects of powerline is also a question of arguments always. This is one of the causes for determining the prices of real estate in the nearby region and lowering the cost of houses near power lines.

The studies on cellular level indicated depression and number of disorders, problem of leukemia and induction of cancer. Workers are always exposed to radiation due to high voltage powerline (HVPL) during erection, repairs and functioning of power lines. Hence some preventive measures are linked with HVPL. These are:

- Only trained and skilled workers are allowed during installation, service and maintenance oh power line.
- The existing power distribution system should be correctly earthened and made deactivated.
- All work associated with live wire should be conducted by trained staff. The trained staff should have capability to measure voltage of live parts, to distinguish the part from other systems and knowledge of safety procedure and ability to handle safety equipments.

While constructing HVPL some guidelines must be followed. The effects of HVPL include dust, noise and vibration from vehicle used for transportation. These problems are for some periods only. But after erection the noise generated through wire
are forever. The effects of magnetic fields generated by these wires are forever and can cause detrimental effects on human health.

Though the frequency of current passing through HVPL is very low as compared with radio frequency sources, its effects cannot be ignored. The high voltage powerlines produces high loss so that they bend earth’s ionosphere as these lines constantly loose energy which cannot be seen and there is no detector to perceive. To find extremely low frequency field one needs low frequency spectrum analyzer. The field can be produced by HVPL at long distance and the intensity decreases from mail line but its biological effects are more significant.

Table 1.3 shows common sources of magnetic fields.

**Table 1.3 Common sources of magnetic fields**

<table>
<thead>
<tr>
<th>Sources</th>
<th>Distance from source</th>
<th>15 cm (mG)</th>
<th>60 cm (mG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave oven</td>
<td></td>
<td>110-300</td>
<td>1-35</td>
</tr>
<tr>
<td>Dishwashers</td>
<td></td>
<td>10-150</td>
<td>3-9</td>
</tr>
<tr>
<td>Refrigerators</td>
<td></td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>Fluorescent light</td>
<td></td>
<td>15-125</td>
<td>10</td>
</tr>
<tr>
<td>Xerox machine</td>
<td></td>
<td>10-250</td>
<td>1-15</td>
</tr>
<tr>
<td>Drill machine</td>
<td></td>
<td>100-300</td>
<td>5-10</td>
</tr>
<tr>
<td>Power saws</td>
<td></td>
<td>40-100</td>
<td>5-50</td>
</tr>
</tbody>
</table>

(Source: National Institute of Env. and Health Sc. 2002)
It should be noted that different models produce different magnetic effects. Peoples staying at long at distance from power lines have exposure continuously and that may be detrimental. There are secondary power lines on the street and colonies, they are more polluting. Our human body acts like living antenna. It can absorb radiation and re-emit energy in the environment. Schools and colleges near powerline full with student can become major polluting source. Table 1.4 shows magnetic field level associated with HVPL

Table 1.4 Magnetic field level associated with HVPL

<table>
<thead>
<tr>
<th>HVPL voltage</th>
<th>Usages</th>
<th>Typical magnetic field produced in mG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Approximate distance from centre of HVPL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 m</td>
</tr>
<tr>
<td>115 kV</td>
<td>Normal</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Peak</td>
<td>14</td>
</tr>
<tr>
<td>220kV</td>
<td>Normal</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Peak</td>
<td>40</td>
</tr>
<tr>
<td>500 kV</td>
<td>Normal</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Peak</td>
<td>62</td>
</tr>
</tbody>
</table>

(Source: National Institute of Env. and Health Sc.2002)

These values are for general information
List of health problems associated with HVPL are listed below.

1. Different types of cancer
2. Development in tumor
3. Leukemia
4. Damage of skin
5. Changes in cell action
6. Disturbance in sleep
7. Sensitivity and memory transform
8. Effects at genetic level
9. Deficiency in hormones and glands
10. Behavioral and psychological changes
11. Deficiencies in immune systems
12. Disorder in nervous system
13. Lack of proper fetal development

Problems due to geopathic stress

Geopathic stress is event take places in nature. The common underground water system produces the stream currents in the water. Peoples staying above the waterline gets affected by such waterlines. Geological faults and stone henges as shown in Figure also create geopathic stresses. If one construct home over natural geopathic zone, people staying in the zone get affected even plants and animals are also suffered by the energy generated in such cases.
Fig 1.4 shows geopathic stress generated by stone henge and its effect on plant development.

![Image of geopathic stress]

**Fig.1.4: Geopathic stress due to stone henge and effect of Gs zone on tree**

Geopathic Stress is caused by electromagnetic disruption:

1. Building above underground water
2. Building over a ley line
3. Building near modern electrical or electronic emission
4. Disused mines
5. Geological fault lines

It had been observed that 30% of buildings are sick buildings.

Worse in combinations or ‘crossings’

Following health problems are connected with geopathic zones
1. Continuous headaches

2. Sadness

3. Nervous state

4. No enthusiasm in life

5. Induction of impatience

6. Short temperament

7. Very poor appetite.

8. Food problems

9. Loss in memory

10. Sleeping and dreaming problems, sleep walk

11. Allergic reaction problems

12. Baby staying in that area are continuously crying

13. Problems of baby wetting beds

14. Hearing problems

15. Chronic disease

16. Effects on plants and animals

17. Possibility of road accidents in Gs zone

While planning and designing of housed and constructing roads geopathic stress should be considered. Even staying near geopathic zone invites number of health consequences. Staying in such geopathic stress affected home should be avoided.
1.5 OBJECTIVES OF THE STUDY:

The present study is aimed to study the effects of electromagnetic radiation on human body. For this the effects on cardiovascular and respiratory system is considered. Electromagnetic radiation produced due to mobile phones, high voltage powerline and geopathic zones are considered for present study.

The specific objectives of the study are:

1. To collect the information about electromagnetic radiation through literature and articles.
2. To prepare a questioner for studying the effect of cell phone radiation and its impact.
3. To conduct a survey of people using mobile phone and those staying near mobile towers about their health problems.
4. To give advisory and interactive information about the various sources to the society.
5. To aware the participants involved in study about health hazards of electromagnetic radiation due to various sources giving electromagnetic radiation out.
6. To select healthy volunteers for experimentation by measuring their health parameter, body mass index and obesity,
7. To evaluate the effect of mobile phone on cardiac electrical activity by examining heart rate in case of normal and healthy person in laboratory.
8. To calculate heart rate to evaluate the effect of mobile phone on cardiac electrical activity by keeping mobile phone in the various ring tone, vibration tone, ring and vibration tone combined and in the silent mode.
9. To compare the heart rate in for the cases when mobile phone was used in various ring tones various tone.
10. To observe the effect of continuous communication using mobile phone for one hour.
11. To see the influence of 20 minute communication using mobile using mobile phone on health parameters like blood pressure (systolic and diastolic), heart rate, and respiration rate, percentage of saturated oxygen in the blood and body temperature.

12. To find out the significance of study paired t test in mobile study.

13. To study the effects of electric high voltage powerline on health parameter for a 30 minutes.

14. To observe effect of HVPL on blood pressure, heart rate and respiration rate, pulse rate, saturated oxygen in the blood and body temperature.

15. To find geopathic zone sites using dowsing method.

16. To study the effect of geopathic stress on human parameters by recording blood pressure, heart rate, respiration rate, pulse rate, percentage of saturated oxygen in the blood and body temperature.

17. To select statistical method to find whether these changes due to various stresses are significant or not.

18. To compare the effects of radiation due to mobile phone, high voltage powerline voltage and geopathic stress zone.

19. To suggest possible methods to minimize the electromagnetic radiation to avoid ill effects of EMR.

The work in the present thesis is bases on the objectives mentioned above.

1.6 IMPORTANCE AND SCOPE OF THE STUDY:

Scientists feel that, there is an urgent necessity to continue more and more investigations in order to study of effects of RF-EMF radiation. More focus should be given to the study of effects in the early stages of human being and radiation exposure in animals. There are studies in this regards which had given alarming bell. Bioinitiative report published in 2012 had given warning in the report about this radiation present twenty four hours at anywhere.
The media and news papers had taken care of all these happenings. Times of India, Indian Express, Daily Bhaskara and many of local news papers had given wide publicity of Bioinitiative reports and articles related with radiation hazards. They had published report of possibility of cancer due to RF radiations. Some people and NGO also had filed cases against erection of mobile towers in their area. Even some Bollywood actresses are making people aware of such incidences.

In the meantime, one should take the preventive attitude to lessen RF-EMF radiation wherever possible. Effects of cell phone towers radiation can be minimized by shuffling towers away from thickly inhabited areas, raising height of towers or altering the direction of the antenna. It is necessary to have small towers in stead of a huge structure.

Human being has various bioelectrical systems like cardiovascular system, respiratory systems, nervous system, digestive system reproductive systems etc. There are signals related to working of specific organs. Any dysfunctioning of these organs are systems are reflected in these bioelectric signals. These bioelectric signals are also known as biopotentials. The major bioelectric signals are listed below.

- Electrocardiogram
- Electroencephalogram
- Electromyogram
- Electroretinogram
- Electrooculogram

The proper functioning of these systems decides health condition of the human body. During functioning, these systems produce electrical signals within body. These signals provide useful information about functioning and abnormality in the systems of body.
Among these, electroencephalogram is associated with brain activity. Sleep disturbance and mental health can be studied using it. Even electromagnetic radiation causes sleep disturbance. Electromyogram is associated with muscle activity. It is useful in muscular treatment.

Remaining two i.e. electroretinogram and electrooculogram are associated with eye, a vital organ in vision. Retinal defects are reflected in electroretinogram while problems in eye movement are reflected in electrooculogram.

Electrocardiogram associated with working of heart. Any irregularities in heart rate, amplitude and or even periods of various waves indicate the abnormality of a patient. Now a day’s numbers of heart patients are increasing. Even young generations are going to be victims of heart stroke. The most probable cause of all these happening around us mainly stresses generated in day to day life. It is believed that main causes of stresses are:

- Change in life style
- Lack of exercise
- Diet and habits
- Attraction of fast food
- Heredity
- Constant use of communication technology
- Lack of healthy interactions between friends
- Generation gap between parents and new generation
- Association with other disease like diabetics
- Stresses generated in day to day life.
Our hearts is regulated by heart muscle generating signal of one millvolt which can be observed on electrocardiogram. Similarly exposures due to EMFs can intermingle with these biological processes in the human body. In some cases, exposure of EMF can cause discomfort and illness [9].

Several scientific researchers confirm that electromagnetic fields are biologically active and show its effect on in flora, fauna and in humans, which could have main public health punishment. Every day, intensity of radiation exposure for non-ionizing electromagnetic radiation has considerably exaggerated in the last few years due to developments in technology and massive increase of these devices.

Non-ionizing electromagnetic radiation (NI-EMR) includes a broad range of frequencies. It includes extremely low frequency magnetic fields obtained from the power lines up to microwave radiofrequencies. Functioning of frequency modulation (FM) and television broadcast stations, wireless technology devices like mobile phones and masts, cordless phones, Wi-Fi routers and units are within this range non ionizing radiation.

The exposure radiation due to these sources raised concern about harmful effects and is the issue of intensive scientific studies around the world. Such studies comprise epidemiological, clinical, in vivo and in vitro studies.

The rate of scientific study accelerated after 2010, when the World Health Organization announced the implementation of the International EMF Project’s RF Research Agenda. According to agenda, “research topic for measurement surveys to characterize population exposures from all radio frequency (RF) sources with a particular emphasis on new wireless technologies should be given” [10]. This is the cause to believe adverse effects of RF radiation.

Biological effects are capable to gauge responses to a stimulus or to a change in the surroundings. These changes are not basically damaging to health in large extent. For example, listening to music gives pleasure, reading a book in spare time, eating an apple
when hungry or playing tennis for exercise will produce some kind of biological effects in the body.

The body has complicated systems to adapt many such diverse effects we experience in our daily life. Continuing transformation in the biological system forms a normal part of our lives. But, the body does not have satisfactory reimbursement mechanisms for all biological effects taking in our body. This is due to various stresses in the environment and stresses generated due to modern sophisticated technology based applications. A harmful health effects cause weakening of defense mechanism of the exposed human beings. It is confirmed that electromagnetic fields above definite levels of electromagnetic radiation exposure can produce harmful biological effects.

Many experiments with healthy volunteers showed that short-term exposure at the levels present in the environment or in the house do not cause any noticeable detrimental effects. But exposures to higher level that might be harmful. Higher radiation exposure is restricted by authorities at national and international level.

Scientific knowledge in this area is now more widespread despite the feeling of some people that more research is necessary. Word Health Organization concluded that current evidence does not confirm the existence of any ill health consequences from exposure to low level electromagnetic fields based on present available work. However, some gaps in knowledge about biological effects exist and needs further research. Study of electromagnetic radiation on health is a step in this direction.

The study reported in the thesis is aimed to study the various possible effects of electromagnetic radiation sources on human health.

The sources used for study include:

I. mobile phone,
II. mobile tower
III. electric power line and
IV. Geopathic stress (The energy emitted by the earth at a specific surface location).
**Hypothesis:**

The experiments were carried out with the objectives to test the hypothesis that

- Electromagnetic radiation affects health parameters of healthy person.

The hypothesis has two parts.

**Null hypothesis**

It is the hypothesis indicating that the process of investigation does not change with other state. In the experiment controlled observation will be compared with the observation noted under stressed conditions.

**H0:** There is no effect of electromagnetic radiation on human health.

In the context of analysis, the observations under the effects of electromagnetic radiation are compared with controlled observations. If both observations are equally good, then null hypothesis is said to be true. Against this, if stressed observations are superior or inferior to normal (or control) observations, we then state that alternative hypothesis is true.

**Alternate hypothesis**

**H1:**

1. There is an effect of electromagnetic radiations from mobile tower on human health.

2. There is significant effect of mobile phone on cardiac electrical activity and health parameters. At various tones

3. There is significant consequence of mobile phone on cardiac electrical activity and health parameters when a mobile phone is used continuously.
4. There is noteworthy effect of continuous talk about 20 minutes on mobile phone on the health parameters like B.P. (Systolic and diastolic), pulse rate, respiration rate, SpO2 and body temperature.

5. There is significant effect of radiation high voltage electric powerline on human health parameters.

6. There is significant effect of geopathic stress on various cardiac activity

7. There is significant effect of geopathic health parameters like B.P., pulse rate, respiration rate, SpO2 and body temperature.

In this present research work the measurements were recorded for controlled condition conditions. Then same observations were us call, in stressed condition using same instruments. Stresses included are mobile phone various ring tone effects and continuous talk. Other stresses conditions considered are seating under high tension power supply and lying in geopathic zone.

In the work null hypothesis will be tested first using paired student’s ‘t’ test and calculating probability value. If null hypothesis is found to be true alternative hypothesis will be rejected, otherwise alternate hypothesis will be accepted. Probability or p value p < 0.05 is considered as significant.

The study under influence of mobile phone in various ring tone and during continuous communication, high voltage powerline and geopathic zones include

- Survey of mobile phone users and the peoples staying near base tower stations in the community.
- measurement of heart rate
- Measurement blood pressure,
- Measurement of respiration rate
- Measurement of pulse rate
• Measurement of saturated oxygen

• Measurement of body temperature

All the studies are taken by adopting methodology in consultations of experts working in respective areas. Their significance is tested by available mathematical tools. Finally these results were compiled to obtain acceptable solutions.