

Benefits and hazards of electromagnetic waves, telecommunication, physical and biomedical: a review

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Abstract. – OBJECTIVE: The aim of this paper is to review the current literature on electromagnetic radiation (EMR): physical, biophysical, and telecommunication. The widespread application of EMR in modern technologies requires telecommunication and healthcare professionals to possess some knowledge of its physical and biological properties. In this review article, we will discuss biophysical principles of EMR, its interactions with living organisms and its application in clinical practices. We will discuss here beneficial as well as hazardous effects of EMR. We will also discuss the safety guidelines.

Key Words

Electromagnetic radiation, Wi-Fi, Mobile phone, Microwave, Computer, FM towers, Magnetic resonance imaging, X-ray computed tomography (CT), Chemotherapy.

Introduction

Electromagnetic Radiations

Radiations consist of both electric and magnetic fields. They are coming from natural and man-made resources. EMR is present in some scenario of everyone's life¹. Some of the most common sources of electromagnetic fields that everybody experiences are the solar radiation, the electric current that supplies household (Mobile Phone, Television set, Wi-Fi, Microwave, Computer, etc.) and antennas for telecommunications²⁻⁸. Artificial resources are used to generate high-level electromagnetic radiations which may be typically found in medical devices such as Magnetic Resonance Imaging (MRI), laser lithotripsy, X-ray Computed Tomography (CT), radiation

therapy, chemotherapy, immunotherapy, Positron Emission Tomography (PET) etc. In a residential environment, the diffusion of the induction cooktop, hairdryers, cordless phones, modems, routers, appliances, alarm system, etc. increases the possibility of domestic exposure to magnetic fields. Nevertheless, electromagnetic fields can also be used for the treatment of different diseases (e.g., cancer, kidney stones, gallstones, brain, liver etc.)⁹⁻¹³. The practicality of above-described technologies is due to the range of frequencies decreasing from ultra-high frequencies to extra low frequencies available in the electromagnetic spectrum. This EMR spectrum includes ionizing and non-ionizing radiations. Figure 1 shows EMR spectrum signifying frequency range of Ionizing and Non-Ionizing radiations.

Electromagnetic Radiation Spectrum (Ionization and Non-Ionization)

The EMR spectrum is widely used in different areas of science and technology. EMR can be broadly divided into two categories: ionization and non-ionization. Ionizing radiation has high energy as compare to non-ionizing radiations. The ionizing radiations have a frequency ranging from 1 PHz (petahertz) to 10 ZHz (zettahertz), which includes X-rays and Gamma rays. The non-ionizing radiations have a frequency ranging from 1 to 1000's of THz (terahertz). It consists of Microwave (MW), Infrared (IR), Visible Light (VL) and Ultra-Violet light (UV) extremely low-frequency radiation (ELF). Ionization radiation has the capacity to cause changes in the structure of atoms or molecules by ionization, so that's why ionizing radiation can cause damage to living atoms/molecules and also have the tendency to cause changes in the structure of DNA in the living organism¹⁴.

Benefits and Hazards of Electromagnetic Radiation in the Field of Physical Health and in the Telecommunication Sector

The telecommunication devices (Mobile Phone, Wi-Fi, Computer, Television, etc.) have proved to be revolutionary effects in terms of communication with anywhere and anytime in the whole world, but it is mostly accompanied with the EMR hazards. The human body has the ability to absorb these radiations might be harmful and can cause even different disease like cancers, mental disorders, neurologic illnesses, fetal abnormalities, cardiovascular diseases etc.¹⁵. EMR has very beneficial uses of our daily life to make it more comfortable and easier. Nowadays, we can talk to anyone on a mobile phone through the Internet: it is because of EMR, since these waves can transmit signals for very long distances. So EMR has the key roles in making our lives more comfortable.

Mobile Phones

In the present era, the mobile phone has played a vital role in our daily life activities. Recently mobile phone is an integral part of business, commerce, studies, and society. Mobile phones are very useful for quick information exchange and an important tool in emergency situations. People use their mobile phones for various purposes such as:

1. Text messaging
2. Photography or taking pictures
3. Making videos, Sending photos via Bluetooth
4. Accessing the internet, sending or receiving emails
5. Playing video games
6. Listening music
7. Recording video
8. Downloading various applications such as WhatsApp Messenger, WeChat, Viber Messenger, imo free video calls and chat etc.
9. Using social networking site like Facebook, Twitter, Skype-free IM and video calls etc.
10. Online banking and business management
11. Video call or video chat.

This work concluded that a mobile phone is necessary for college students to keep in contact with their families and friends.

The main objective of this study is to describe the answer to the following two questions:

1. May the excessive use of mobile phones in the vicinity or near the human body cause many harmful diseases?
2. How can mobile phone subscriber minimize the risks associated with its exposure?

This paper will attempt to answer this question, but conclusions are rarely definitive. The objective of the present report is to explore the association of using mobile phones with health hazards¹⁶⁻¹⁸ such as:

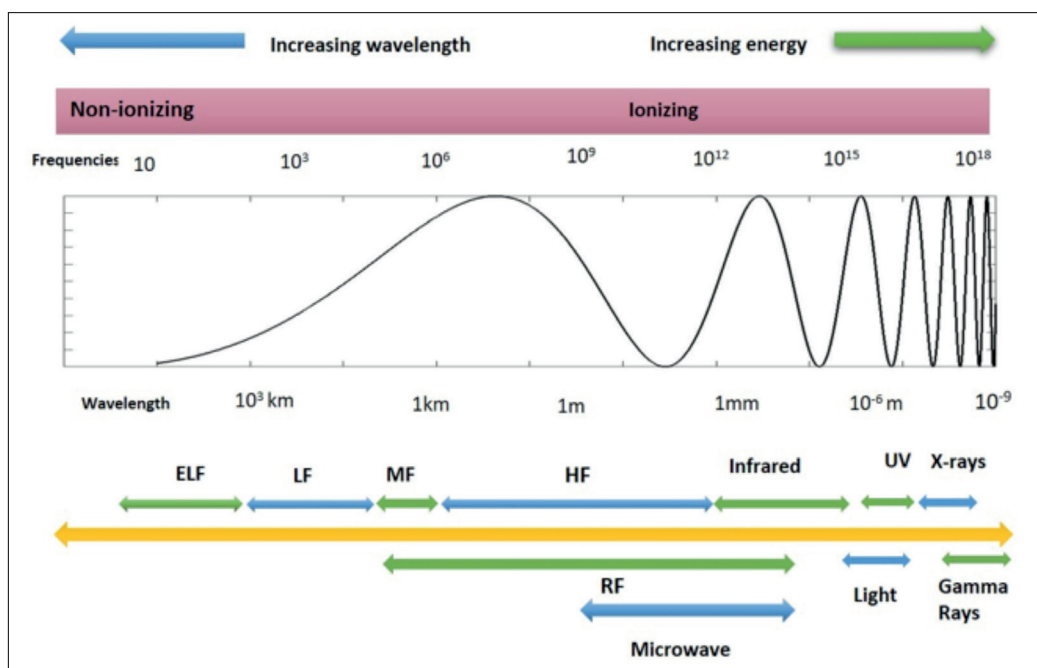


Figure 1. The Electromagnetic Spectrum.

1. Fatigue
2. Headache
3. Dizziness
4. Tension
5. Sleep disturbance

It is the cause of hippocampal lipidome as proved by the experiment on a mouse¹⁹⁻²¹. It disturbs our brain and central nervous system, leading to memory loss²². The excessive use of mobile phones can cause vision and hearing symptoms in the population and also leads to an increase in social awareness of health associative problems²³. The present review literature was designed to investigate whether the symptoms of health diseases reported by young people may be linked with the use of mobile phone and to analyze its effects on young people health²⁴. In the present paper, we have mentioned some precautionary approaches to minimize the health risks associated with mobile phone exposure. Our suggestions are to minimize the time per day spent on mobile phone calls, refrain the use of the mobile phone when its signal coverage is weak, and avoid the use of mobile phone close to our body²⁵.

Wi-Fi

The present report investigated the effects of EMR induced by Wi-Fi have many benefits and adverse effects. Wi-Fi LANs allow fast network information, also beneficial in reducing the cost for wiring installation and to give industrial subscribers more flexibility anywhere at any place, whenever they want to do work. Home subscribers also want to abstain installing wiring process. Wireless Internet routers or Wi-Fi modems use possibly dangerous electromagnetic radiation to send their signals to your computer through walls. If you have a wireless Internet router set up in your home or office, you will be exposure to EMR. Wireless access to the Internet is now commonly used in schools/colleges. Many schools/colleges provide laptop to each student with Wi-Fi connection, which is utilized for training and educational purpose²⁶. In the literature, many experiments on rats by using Wi-Fi signal are reported. The main objective of these experiments is to identify the changes in the rat after the exposure of EMR with different frequency ranges. The effects of long-term exposure to Wi-Fi type radio frequency (RF) signals (2.40 GHz), two hours per day during one month at a specific absorption rate (SAR) of 1.60 W/kg may cause Alzheimer's disease²⁷. It may also cause some

oxidative stress parameters in rat kidney²⁸. The exposure of EMR (2.45 GHz) may cause many changes in the rat brain and expression of fall in brain antioxidants²⁹. Avendano et al⁵ reported that wireless connected laptop on the lap near the testes may have effects on male fertility and increased DNA fragmentation.

Microwaves

Our main objective is to investigate the effects of EMR from microwave ovens to the health of the people coming across its use. Most of the people believe that microwave ovens may cause diseases such as cancer and the food prepared by them becomes harmful. But there is no scientific experimental evidence. EMR from microwave oven has the capability to penetrate in many things like water, ice, smog. It affects the nutrient capability of vegetables making them unhealthy for human use, such as it destroys the anti-cancer ability of different vegetables like garlic as demonstrated in several studies to describe the effects of microwave oven heating destroyed garlic anti-carcinogenesis property, which is related with active allyl sulfur compounds³⁰. The long terms exposure of low-frequency EMR from home appliances can cause health problem such as¹⁴:

1. Hyperactivity
2. Sleep disorder
3. Emotional instability

TV, Cell Phone and FM Towers

In the recent past, long-term exposure of EMR from Cell phone towers, TV and FM towers have caused serious health problems³¹. Hocking et al³² in Australia reported that the incidence of leukemia, tumors, and cancer was more in the people residing near to TV, cell phone and FM towers, while those who were residing far away from the towers found fewer chances of diseases in them. But he found that the children were getting many severe effects of leukemia, tumors diseases rather than adults living in the same areas. Cooper et al³³ collected cancer data from the years 1987-1994 which were investigated from the West Midlands Cancer Intelligence Unit database (Birmingham, England). They studied all types of cancer; for each of them, 10 bands of males, females and adults were selected. A number of leukemia cases were calculated for all of these members on the basis of sex, social issues. This research gives evidence from stone's test showing more risk of leukemia in females/children as compared to males.

It is reported in the literature that people living near antennas were suffering from a high risk of diseases such as³⁴:

1. Cardiovascular problems
2. Skin diseases
3. Irritability
4. Visual disruptions
5. Hearing problems
6. Depression

Dianah et al³⁵ in Kaula Nerus described the enhancement of rapid growing telecommunication technology by installing many TV, cell phone and FM towers as a first step to help in the advancement of growing global technologies. The EMR exposure level was investigated using spectrum analyzer through a Circular Patch (CP) antenna. They used a spatial model to evaluate their data and results and stated that this model can help in exploring the clear vision of EMR health risks. The EMR effects on human body cells act by removing calcium ions. Calcium ions leakage from brain cells and other parts of the body can cause pain and other diseases in the human body³⁶.

EMR Effect on Biotic Systems

EMR from TV, cell phone and FM towers affects the biotic system such as animals, birds, plant, etc. EMR effects are relatively larger in flying birds, sparrows, pigeons and bees in comparison with humans. The reason is that the overall body structure of bird is small having less weight. They get heated up very frequent and these radiations can cause adverse effects on their navigational system. Some effects are given in the next section.

Effect on Honey Bees

Taye et al³⁷ reported the adverse effects of EMR on honey bee colonies near to the cell phone towers. In the US, the increasing influence of EMR pollution associated with the sudden loss of bees was observed a few years back. This type of honey bee's loss is known as colony collapse disorder (CCD), where bees cannot detect the right way to find the hive due to the consistent EMR pollution. CCD has spread in many developing countries like England, Spain Germany and Italy³⁸.

Effect on Birds

When migratory birds come in direct contact with EMR from TV, cell phone and FM towers, they become entirely confused and disoriented from their right path and undetermined navigational abilities. The sense of direction of a large

number of migratory birds like sparrows, pigeons are destroyed due to the interference from mobile phone masts. Many species of birds die each year from the overlapping with TV, cell phone and FM towers all over the world during migration. For navigation, mostly birds might be likely adopting earth's magnetic field. Microwaves from communication resources could be seriously disorienting and these are the main cause of accidents occurring to birds during night-time. Dongre and Verma³⁹ have investigated the remarkable decline of house sparrow in London: a 75% fall since 1994.

Effect on Mammals and Amphibians

Burchard et al⁴⁰ reported that the grazing of cows near to the TV, cell phone and FM towers having overall general health problems like defective embryos, birth deformities, and behavioral problems, meanwhile grazing of cows away from the towers have improved health. Moreover, exposure of EMR to dairy cows can cause the changing composition of milk, leading to a decrease in the production of milk and fertility problems. Similarly, long-term effects of EMR can also cause reproductive and developmental problems of domestic animals like dogs, cats, rabbits, etc. In the recent research conducted on bats colonies near the towers, they found conflicting behavioral changes in bats⁴¹. EMR from towers is a possible source of declining some amphibian populations. In a study conducted on amphibians they have found morphological abnormalities, increase in the heart rate, changes in blood count, allergies, etc⁴². Researchers also described the positive effects of EMR on mammals, like Cecconi et al⁴³ that suggested how low power EMR exposure may be used to improve the mammalian female reproductive system by controlling the follicles growth rate to proceed a developmental stage that is an important pre-requisite for reproductive achievement.

Effect on Plants

Studies have shown the effects of cell phone EMR on growth and synthetically changes in plants. Alattar et al⁴⁴ reported characteristics of seeds by exposing radiation from Wi-Fi router. The experiment was accomplished by test seeding for four weeks. Finally, the research concluded that these radiations may cause many changes in the weight and growth of plants, thickness level of the stem, etc. The progressive decline of trees near to cell phone tower has also been reported. EMR can produce heat. Due to this heat,

the micro-organisms present in the upper surface of earth soil would be killed⁴⁵. In the literature review, there are many advantages of EMR in the agriculture sector such that the use of EMR on rice plant in a microgravity environment can enhance the growth of plant rather than the normal growth⁴⁶. Pietruszewski et al⁴⁷ described the tool of EMR stimulation on seed may increase the plant growth.

Safety Guidelines in Telecommunication Sectors

From a scientific point of view, long-term effects of EMR from telecommunication towers might be harmful to the human, birds, animal, and ecosystem. To reduce the long-term effects of EMR, some recommendations are suggested, such as: network operators must be instructed to apply reduced cumulative power density near to residential areas, school, hospital, office buildings, and visiting places. People should have knowledge of long-term effects of EMR hazards, so that they may have network issues (especially all those people, who are living far away from the cell tower) due to lower transmitted power, but it is for their overall health favor. Thus, the solution is to install several numbers of cell-phone, TV and FM towers with lower transmitted power. In this way, the power efficiency of the tower will be reduced. So that health heating effect will also be reduced⁴⁸⁻⁵⁰.

Benefits and Hazards of EMR: Physical and Bio-Physical Cancer Treatment Techniques

EMR associated with the study of nanotechnology, searching natural phenomena and its applications. Further progress of this area of expertise strongly affects both biomedical engineering and medicine. Magnetic nanoparticles are the most popular topics in life sciences and healthcare. Magnetic hyperthermia treatment is used to explore the highly effective carcinogenic cell destructions. Moreover, magnetic hyperthermia, which is based on magnetic nanoparticle to remotely, generates heat when EMR is applied. This hyperthermia heating technique is used for the treatment of cancer⁵¹. Recently, a significant progress has been made in the field of cancer treatment technique by using EMR. Treatment methods are based on radiation therapy, hormonal therapy, chemotherapy and immunotherapy⁵². UV radiations from the sun are harmful to our normal skin cells as well as these radiations are ben-

eficial to the destruction of cancer cells⁵³. During the treatment of cancer patients, internal organs are visualized deeply by using (X-rays and gamma rays)⁵⁴. Frequent use of these radiation therapies can also cause harmful effects on the human body. Long-term use of these examinations and treatment are associated with cancer risk in clinical practice. Peters et al⁵⁵ described the chemotherapy radiation treatment of women at high risk of recurrence cervical cancer after a few years.

Disease Diagnoses with Imaging Techniques

EMR is used in imaging studies like radiography, angiography, and computer tomography scanning. Wernick et al⁵⁶ reported that multiple image radiography technique is used for more accurate images of a biological specimen. In the present study concluded that angiography showed the clear vision of the blood vessels and the other organs of the body especially with the heart chamber, arteries, narrow veins, etc. X-ray computed tomography (CT) was the first modern imaging technology, introduced in 1972. It is used for imaging of the whole body in 5 to 20 minutes with a sub-millimeter isotropic resolution⁵⁷⁻⁵⁹. Phase contrast X-ray imaging is a remarkable technique for analyzing deep structure inside biological soft tissues. It is used for observing the three-dimensional structure of infected tissues⁵⁶. Synchrotron radiation micro-tomography is used for the analysis of the composition and deep structure of all types of materials and biological specimens⁶⁰. Magnetic resonance image (MRI) is a wonderful technique for taking detailed pictures inside the human body. It is used to diagnose different diseases and injuries inside the human body such as brain injury, spinal cord injury, and blood vessel damage, cancer cells, heart diseases, and blocked blood vessel. An electromagnetic actuator was designed for magnetic resonance electrography (MRE). The actuator is unique since it is simple, portable, and capable of brain, abdomen, and phantom images. The relatively easy setup procedure and simple design indicated that the actuator system had the potential to be applied in many different clinical studies^{61,62}.

All these techniques are associated with damages to chemical bonds between living tissues. Long-term use of X-rays CT scan can also modify genetic properties in a living organism and cause variation leading to cancer⁶³. EMR exposure to high-frequency waves like X-rays, Gamma rays, ultraviolet rays, etc. from above-mentioned tech-

niques is a source of serious biological changes and harmful effects in a living organism. Anjum et al⁶⁴ reported that exposure to dental X-rays may be associated with an increased risk of thyroid cancer.

Urinary, Kidney and Gall Stones Treatment Techniques

In the current research resulted that EMR-generated extracorporeal shock wave lithotripsy has found many applications in clinical biology. It has replaced the surgical treatment of renal and ureteral stones. Moreover, lithotripter combined with radiological and endo-surgical techniques has been used for the treatment of complex stones in the upper urinary tract, complex kidney stones and gallstones⁶⁵. EMR can also be applied for modern technologies such as electrohydraulic lithotripsy and laser lithotripsy. Laser lithotripsy is a popular method of fragmentation in urinary stones. Laser lithotripsy may also be used for the optimize fragmentation of harder gallstones. This treatment is used for patients having a stone size of 30 mm or less and having symptoms of the disease⁶⁶. Multiple lithotripsy examinations do not show a high risk, however high dose of radiations may also cause damages in our human organs⁶⁷. In the present era, we have to minimize the effects of these radiations by using safety aids like wearing safety dresses and other safety objects. So that, we can save our environment and living beings. Use of these radiations for beneficial purposes can make this world like a paradise. In the next section, we will briefly discuss safety guidelines.

Safety Guidelines in Hospital Laboratories

Briefly refer to the guideline of⁶⁸: all people who work in the areas of radiations exposure must be aware of the EMR associated with health problems.

All those people, who come across with radiations exposure for the treatment of the patients like nurses, doctors, medical staff, etc. must receive training. The main content of the training should be based on radiation safety practices and potential health risks.

Health care professionals must avoid direct contact with radiation equipment sources without wearing gloves and EMR safety shielding dresses.

Do not smoke, drink and eat in the radiation exposure laboratories.

The hospital administration needs special care and knowledge, when the patient is placed too close to the EMR exposure sources.

Conclusions

The health problems due to long-term effects of EMR from telecommunication and biomedical devices have been addressed among the people all over the world. The organizations like World Health Organization (WHO), Federal Communication Commission (FCC), and International Commission on Non-Ionization Radiation Protection (ICNIRP) have recommended some safety guidelines for the protection of all living beings. In the present review, we have examined several research papers, on living beings like rats, cows, plants and humans etc. By experimental strategies it was identified that long-term effects of EMR can possibly cause different diseases in a living being. Even if all those people are attentive to the long-term effects of EMR hazard, they may not have the other option to move away from it, if the cell phone, TV and FM tower are installed near their houses, schools, public transports, and hospitals etc. But the matter is controversial. Meanwhile, EMR has many advantages in biomedical and telecommunication technologies. So, it is impossible for us to stop using these radiations. However, researchers will try to find out the possible solutions, which may be expensive. But we will easily reduce the health risk in all living being like humans, animals, and birds.

Conflict of Interests

The authors declare no conflict of interest

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