

AERB

International Agency for Research on Cancer



World Health
Organization

PRESS RELEASE
N° 208

31 May 2011

IARC CLASSIFIES RADIOFREQUENCY ELECTROMAGNETIC FIELDS AS POSSIBLY CARCINOGENIC TO HUMANS

Lyon, France, May 31, 2011 -- The WHO/International Agency for Research on Cancer (IARC) has classified radiofrequency electromagnetic fields as possibly carcinogenic to humans (Group 2B), based on an increased risk for glioma, a malignant type of brain cancer¹, associated with wireless phone use.

Background

Over the last few years, there has been mounting concern about the possibility of adverse health effects resulting from exposure to radiofrequency electromagnetic fields, such as those emitted by wireless communication devices. The number of mobile phone subscriptions is estimated at 5 billion globally.

From May 24–31 2011, a Working Group of 31 scientists from 14 countries has been meeting at IARC in Lyon, France, to assess the potential carcinogenic hazards from exposure to radiofrequency electromagnetic fields. These assessments will be published as Volume 102 of the *IARC Monographs*, which will be the fifth volume in this series to focus on physical agents, after Volume 55 (Solar Radiation), Volume 75 and Volume 78 on ionizing radiation (X-rays, gamma-rays, neutrons, radio-nuclides), and Volume 80 on non-ionizing radiation (extremely low-frequency electromagnetic fields).

The IARC Monograph Working Group discussed the possibility that these exposures might induce long-term health effects, in particular an increased risk for cancer. This has relevance for public health, particularly for users of mobile phones, as the number of users is large and growing, particularly among young adults and children.



Sustainable Technology and Entrepreneurship

<https://www.journals.elsevier.com/sustainable-technology-and-entrepreneurship>

Review

Mobile phone and base stations radiation and its effects on human health and environment: A review

Nadimikeri Jayaraju^a, M. Pramod Kumar^b, G. Sreenivasulu^c, T. Lakshmi Prasad^{b,*},
B. Lakshmanan^d, K. Nagalakshmi^e, M. Madakka^f

^a Department of Geology, Yogi Vemana University, KADAPA-513006, AP, India

^b Department of Earth Science, Yogi Vemana University, KADAPA-513006, AP, India

^c Dept of Geology, S.V. University, Tirupati- 517 502, AP, India

^d CSIR-Indian Institute of Chemical Technology, Hyderabad, 500007, India

^e Dept of Geology, Govt Degree College, Anantapur-515 001, AP, India

^f Dept of Bioinformatics & Biotechnology, Yogi Vemana University, KADAPA-513006, AP, India

ARTICLE INFO

Article History:

Received 13 September 2022

Accepted 18 November 2022

Keywords:

Mobile phones

Base stations

Radio frequency

Radiation

Thermal

Non-thermal effect

ABSTRACT

A review of the impact of mobile phone and base station radiation on human health and the environment has been presented here. Cell phone is an important invention in human history that has revolutionized people's lifestyles. As mobile phones have become an integral part of human daily routine, the quality of life around the world has improved significantly. However, concerns about the exposure of people, flora and fauna to radio frequencies are not new. The satisfaction and convenience derived from the use of cellular phones is threatened by claims that the radiation emitted by the devices has unfavourable impacts on human health. The effects of radiation may be classified into non-thermal and thermal. Thermal effects are similar to those of cooking in a microwave oven. The non-thermal effects are not properly defined, but it is been learnt that these effects are three to four times more hazardous than the thermal, which remains controversial. A brief picture of the Indian scenario of cell phone industry and the number of mobile towers in India was discussed. The effects of radiation emitted from cell phones and base stations on wildlife, humans and the environment were summarized with suitable examples and studies conducted by various voluntary organizations.

© 2022 The Authors. Published by Elsevier España, S.L.U. on behalf of Sustainable Technology and Entrepreneurship. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Today is the age of wireless communication which gifted us with cell phones. Mobile phones are the recent innovation and a popular mode to communicate nowadays. It is a long-range, portable, and wireless electronic communication device (Das, 2012). The telecommunication sector has exponential growth rate on a global scale and mobile phones are popular and necessary gadget in the modern culture and society which the society people to maintain constant and unlimited communication without limiting their freedom of movement. Since the of on set mobile phones 1980's, the total number of mobile phone subscribers and installed base stations have increased significantly. The report of Ericson mobile subscriptions outlook shows around 8.2 billion worldwide mobile subscribers and projected the figure will reach 9.1 billion by the end of 2027 (Ericson Mobile Subscribers Outlook Report, 2021).

Today's technologically advanced mobile phones can not only receive and make calls, take photos, store data, access email and the Internet, but the introduction of mobile phone applications has changed people's lifestyles across the board. According to one estimate, there were about 4.42 million apps in the Google and Apple stores combined. These devices and mobile apps have proved to be lifesavers when it comes to helping people in emergencies. For example, mobile apps such as 'm-health technologies' are used to prevent or treat childhood and adolescent obesity (Turner et al., 2015). However, individual mobile phones work by communicating with a fixed facility called as a base station or telecommunications structure. The use of mobile phones has increased probably and has been accompanied by a parallel rise in concern about the health hazards associated with exposure to the electromagnetic fields (EMF) generated by these at their installed stations. Mean while the mobile phone and its base station are two-way radios that generate radio frequencies (RF). Since the advent of mobile phones, concerns have been raised about the potential health risks of exposure to RF and microwave EMF (Mehta, 2011). RF radiation is non-ionising radiation with

* Corresponding author.

E-mail address: tlprasad@yvu.ac.in (T. Lakshmi Prasad).

<https://doi.org/10.1016/j.ste.2022.100031>

2773-0328/© 2022 The Authors. Published by Elsevier España, S.L.U. on behalf of Sustainable Technology and Entrepreneurship. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Within 91 m from a mobile tower			
Name of deceased	Year of death	Cause of death	Age at time of death
Radhabai Sathe	2005	Breast cancer	66
Deshpande	2006	Oesophagus cancer	48
Shubhangee Deshpande	2007	Rectum cancer	66
Pujaree	2008	Cancer	46
Gavai	2008	Breast cancer	52
Shah	2009	Cancer	48
Vidyardhar Dev	2009	Liver cancer	52
Ransube	2009	Throat cancer	73
Archana Malvadkar	2009	Spinal cord cancer	17

Source: L. B. Deshpande, who studied the deaths in his Solapur locality since two towers were installed four years ago

Fig. 2. Names of deceased persons year wise.

studied rats exposed to radiation of mobile phones. The investigators attached the mobiles to the sides of the rats' small cages using coaxial cables, allowing for intermittent direct exposure, and varied the intensity of the radiation in each treatment group to demonstrate the range of exposure a human mobile user might experience over the same period of time. After 50 days, the 2 h exposure, the rats' brains showed considerable damaged neurons as well as blood vessel leakage. Higher the radiation exposure, greater the more damage. The control animals, on the other hand, showed little or no damage. If human brains are badly affected, it leads to long-term mental deficits.

In addition, the team also found certain types of nerve damage and the cells in the cerebral cortex and hippocampus, the memory centre of the brain, observed after one to two months, showed changes in the activity of a huge number of gene groups that are functionally linked (www.ehhi.org) (Fig. 4).

Effect on male reproductive system

The Working Group of the Environment studies on 10 humans and a startling variety of concerns in sperm exposed to mobile phone radiation. The most striking finding was that men who

carried their mobile phones in their pockets or on their belts were more likely to have lower sperm counts and/or more inactive or less mobile sperm (Grafström et al., 2008). These results were consistent with similar findings in laboratory animals. Overall, the study results suggest that exposure to mobile phone radiation can lead to a decrease in sperm motility, sperm count, and vitality, as well as increase the scope of sperm damage, DNA damage and changes in sperm morphology. Scientists have not yet found a mechanism by which mobile phone use could cause such effects (Baan et al., 2011; De Iuliis et al., 2009; Kesari et al., 2018; Makker et al., 2009) (Fig. 5).

Studies on the harmful effects of mobile phones on human sperm have been conducted in the Australia, Austria, Hungary, Poland, South Africa, Turkey and United States, using different protocols. Men who carried a mobile phone in their hip belt or on their pocket had 11% fewer mobile sperm than men who carried the phone elsewhere on their body (Sharma and Lamba, 2017). Men who carried a mobile phone on their belt and used it intensively during a five-day test period had a 19% decrease in high-mobility sperm (Kilgallon and Simmons, 2005). Men who talked on the phone for more than an hour a day had 17% fewer high-mobility sperm than men who talked on the phone for

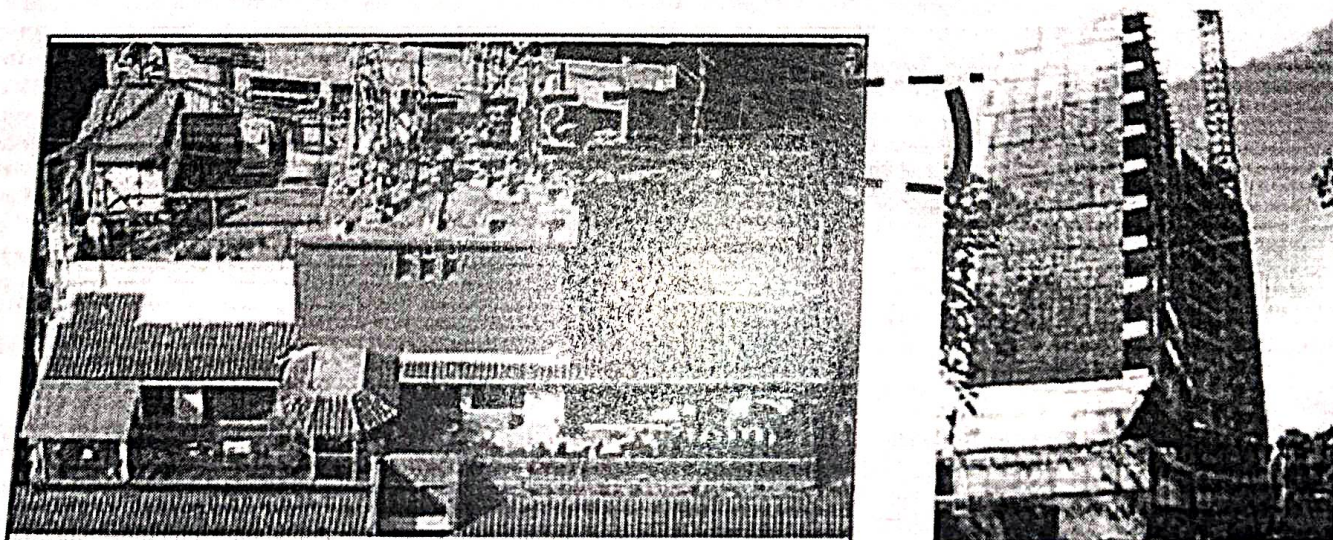


Fig. 3. Mobile towers installed on Vijay Apartments terrace at Carmichael Road, Mumbai.

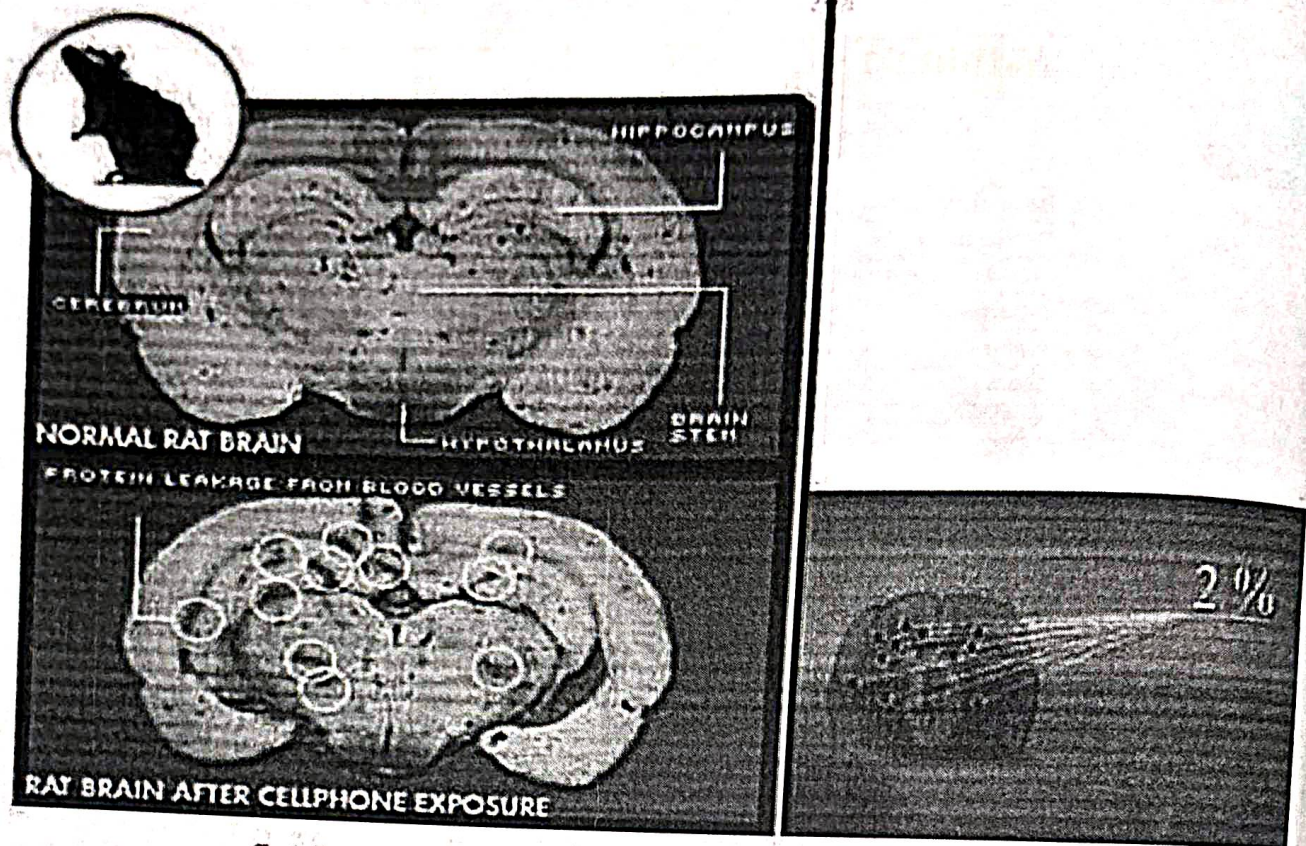


Fig. 4. Shows normal rat brain and rats brain after exposure to cell and base tower radiation.

less than 15 min a day (Surendran et al., 2020). Laboratory studies on the effects of mobile phone radiation on rabbits, rats and other animals have found parallel effects on reproductive health (Fojas et al., 2005; Kesari et al., 2011). All of these studies found a statistically significant association between mobile phone radiation and sperm health. However, opinions differ on the possible mechanism by which mobile phone radiation could cause these changes (Majankot et al., 2009).

The other effects on human health from mobile phones and base station radiation are described in various studies as follows. Headaches, warmth in the ear and burning sensations on the skin of the face were reported (Falzone et al., 2011). Radiation from mobile phones and base stations can trigger Alzheimer's disease by decreasing acetylcholine levels, a chemical in the brain that is crucial for memory and learning (Lonns et al., 2005). Long-term exposure to base station radiation leads to the development of intracranial tumours, neurocognitive symptoms, nerve sheath tumours (including acoustic neuromas) and sleep disorders (Sharma & Lamba, 2017).

Mobile phone use before bedtime delays and reduces sleep, causes depression and confusion, and affects brain physiology. The recent findings are particularly leathai to the children and adolescents as they use mobiles at night and also hold the phone next to their head. This leads to personality and mood swings, depression, poor concentration and lack of academic performance (Sharma & Lamba, 2017).

Effects on infants and pregnant women

Children are more susceptible to mobile phone radiation because of their tiny head and brain, thinner skull bones, more elastic ears, thinner skin, smaller volume of blood cells, and greater conductivity of nerve cells, they absorb more energy than adults and the energy penetrates deeper (Kumar, 2010). The absorption of EMR from a mobile phone (frequency - GSM 900 MHz) by an adult, a 10-year-old

and a 5-year-old child is shown (Fig. 6) (www.mobileindian.com). When the radiation hits the head, it penetrates the skull. The yellow area at the bottom is where the cell phone is at the ear. The radiation penetrates the skull of an adult (25%), a 10-year-old (50%) and a 5-year-old (75%).

The younger the child, the deeper it penetrates because its skull is thinner and still developing. For these reasons, children under 11 should only use mobile phones for short, important calls, as the risk of getting a brain tumour is much greater for them. Brain tumours have now replaced leukaemia as the leading cause of death in infants (Kumar, 2010). For these reasons, countries such as France, Belgium, Finland, Germany, Israel, and Russia have publicly discouraged the use of mobile phones by children. Sweden reported that the likelihood of developing brain tumours is increased by 420% amongst mobile phone users who started using phones as teenagers or younger (ITU, 2011). A pregnant woman and the foetus are both at risk because these RF radiations constantly react with the developing embryo and multiply cells. Microwave radiation can damage the placental barrier, the membrane that prevents the passage of some substances amongst maternal and foetal blood and protects the foetus, which means that pregnant women should avoid mobile phones or use them only in emergencies.

Effects on patients with pace makers

Close and prolonged exposure to EMR can have adverse effects on the heart: Pacemakers, implantable cardiovascular defibrillators (ICDs) and pulse generators can cause cardiac arrhythmias. Radiation emitted from mobile phones and transmission towers can interfere with implanted pacemakers and regularly interrupt the delivery of pulses or create a type of external control pulse that can lead to patient death (Sharma & Lamba 2017).

A Review: Source and Effect of Mobile Communication Radiation on Human Health

Antim Bala Sharma*

*(Research Scholar Department of ECE) SGVU, Jaipur-302017 (Rajasthan), India.
Email: antimbsharma@gmail.com, 91-9462816962*

Dr. O. S. Lamba

(Professor Department of ECE) SGVU, Jaipur (Rajasthan), India.

Dr. Lokendra Sharma

Professor, pharmacology, SMS Medical College, Jaipur, (Rajasthan), India.

Abstract

With improving technology and affordability, the number of cell phone users increases continuously. As the number of base stations required, increases with greater mobile phone use with market competition, and with new technological capabilities. The microwave frequencies used in the mobile communication causes the thermal and non-thermal effects and leaves negative impact up on biological system. The EMR emitted by the mobile antennas used at the base stations and mobile handsets used by user's effects the cell structure of the living beings. Continuous and long term exposure to this radiation can have negative impact on biological system of human beings over the years. EMR are absorbed as it interacts with matter and transfers wave energy into the medium. The amount of RF-EMW radiation energy absorbed by human tissue depends on the frequency, intensity, polarization and duration of exposure. The EMR are also recognized as the major cause of cancer. Studies indicate that the population residing near mobile phone base stations complain of nonspecific symptoms of ill-health such as headache and sleep disturbances. The aim of this paper is to produce an independent review of the recent literature on the possible biological and health effects of low intensity microwave radiation and expected methods to reduce the effects.

Keywords- Electromagnetic Radiations, Base Station, Non-thermal health effect, Specific Absorption Rate, Radio Frequency-Electromagnetic Waves, and biological effect.

increases. The primary lobes exhibit the maximum radiations in horizontal direction. Radiations from secondary lobes range from medium to low [6]. The level of radiation starts decreasing as we move away from the line of antenna to its side lobes. EM radiation from mobile towers depends on frequency, distance and duration of exposure.

B. Radiations from mobile phones

The amount of the power which sent from a base station could vary from cell phone to another one even within the same area, depends on the interfering from obstacles such as buildings and trees. The amount of RF generated by cell phone is usually depends as buildings and trees. The amount of RF generated by cell phone is usually depends on the number of base stations around the area, the cell phone network traffic, and on how far the cell phone from base stations [7]. Cell phones are designed to operate at power levels below a threshold for known thermal effects, radio frequency radiation could produce other kinds of effects, called biological effects. Every mobile phone comes with a SAR rating (although some manufacturers try to hide it). In Figure 3, we show a calculation of specific absorbed radiation (SAR) distribution in an anatomical model of human head positioned next to a 125 mW dipole antenna. The resulted Peak SAR is 9.5 W/kg over 1 mg which is a clear indication of the effect.

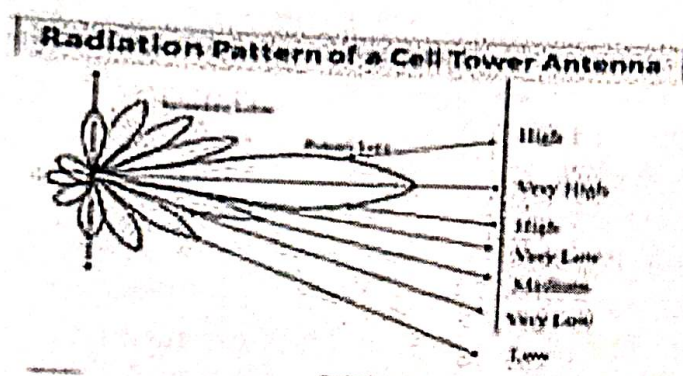


Figure 2. Radiation pattern of Cell Phone Tower

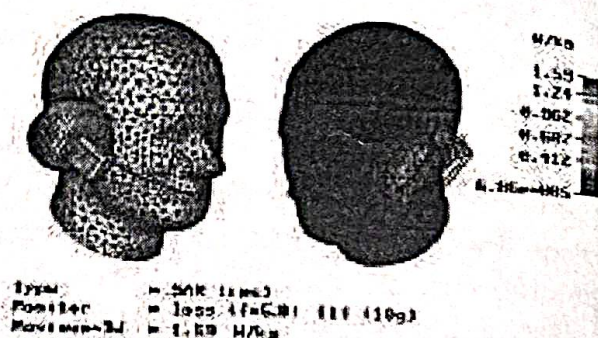


Figure 3: Calculation of Specific Absorbed Radiation (SAR)

The IEEE and many national governments [11] have established safety limits for exposure to various frequencies of electromagnetic energy based on SAR, mainly based on the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines [12].

IV. EFFECT OF EMR ON HUMAN HEALTH

Public is being exposed to continuous, low intensity radiations from these towers. The EMR radiations, also known as electrosmog cannot be seen, smelt or felt, one would

V. BIOLOGICAL HAZARD

There are various short-term and long-term effects from mobile radiations. Several health hazards associated with cell phones and cell towers are-

A. The Blood Brain Barrier

The brain is protected by tight junctions between adjacent cells of capillary walls by the blood-brain barrier (BBB), which selectively lets nutrients pass through from the blood to the brain, but keeps toxic substances out. A single two-hour exposure to a cell phone just once during its lifetime permanently damaged the blood-brain barrier. So there is a risk that disruption of this protection barrier may damage the brain. Hardell et al, [17], and Repacholi et al.,[14], reported risk of developing brain tumor due to the exposure to EMF radiation generated by cell phone. Besides increase in brain tumour and acoustic neuroma, there is an increased risk of several other types of cancers following prolonged exposure to mobile phone/ tower radiation, such as, salivary gland tumors, uveal melanoma, lymphoma, facial nerve tumors, skin, blood, testicular and breast cancer. Interphone study in May 2010 has also found a 'significantly increased risk' of some brain tumors for heavy users of mobile phones (> 20 minutes per day) for a period of 10 years or more. This is later substantiated by International Agency for Research in Cancer (IARC), part of WHO (World Health Organization) in May 2011.

B. Risk to Pregnant Women

A pregnant woman and the fetus both are vulnerable because of the fact that these RF radiations continuously react with the developing embryo and increasing cells. Microwave radiation can damage the placental barrier; the membrane which prevents the passage of some materials between the maternal and fetal blood, protecting the fetus, implying that pregnant woman should avoid exposure to cell phone and tower radiation.

C. Risk to Children

Children are more vulnerable to cell phone radiation as they Absorb more energy than adults from the same phone owing to their smaller head and brain size, thinner cranial bones and skin, thinner, more elastic ears, lower blood cell volume, as well as greater



A Review: Source and Effect of Mobile Communication Radiation on Human Health 431

conductivity of nerve cells and the energy penetrates more deeply. Children's cells reproduce more quickly than adults which make cancers more deadly. Tracy Lightfoot et al., [13] found memory errors, cognitive function and mental health problems due to exposure to EMF. Ching et al., [15] has confirmed decreases in skin resistance [16].

Adverse impacts of mobile phone tower radiation on human health

Abstract

These days mobile phones have become associated with elementary a part of our life, this is often one in every of the foremost necessary mediums for communication. Consequently, several portable towers are planted to hide additional areas, particularly in huddled cities and concrete areas. Now, the bottom stations made on these locations have transceivers that employ mistreatment frequency (RF) waves to determine communication among users within the mobile network. Because of the variety of base stations needed it will increase with bigger portable use with market competition, and with new technological capabilities. The microwave frequencies utilized in mobile communication cause thermal and non-thermal effects and leave a negative impact on the biological system. The quantity of RF-EMW radiation energy absorbed by human tissue depends on the frequency, intensity, polarization, and period of exposure. The EMR is recognized because of the major reason behind cancer. This review paper presents the potential biological and medicine health effects of high-intensity portable tower radiation.

Keywords: mobile phone, electromagnetic radiation, cell phone tower

Volume 7 Issue 5 - 2020

Shriyash Mohril,¹ Mahipal Singh Sankhla,² Swaroop S Sonone,³ Kapil Parihar,² Rajeev Kumar⁴

¹Process Associate, Roboticwars Pvt. Ltd. Noida, India

²Research Scholars, Department of Forensic Science, School of Basic and Applied Science, Galgotias University, India

³Student, Forensic Science, Government Institute of Forensic Science, India

⁴Associate Professor, Department of Forensic Science, School of Basic and Applied Science, India

Correspondence: Mahipal Singh Sankhla, Research Scholars, Department of Forensic Science, School of Basic and Applied Science, Galgotias University, India.
Email: mahipal4n6@gmail.com

Received: September 22, 2020 | Published: October 27, 2020

Introduction

Nowadays, the tremendous growth in technology and smart devices has seen users get caught using them in their daily habits. Smart devices became part and parcel of our lifestyle, a feat that has turned top communication businesses to develop more advanced transmission means can cover this extensive demand. The transmission mediums are the mobile towers, which comprise antennas and base transceiver stations that use frequency (RF) to repair communication channels for users.¹ People use mobile phones for communication reception, work, or anyplace their but just a couple of are concerned about their wellness indications and potential security measures. Most of the People aren't aware of mobile and cell tower radiations which are very dangerous due to electromagnetic radiation (EMR) exposure.² Cellular wireless communications became omnipresent. Wireless technology is predicated on extensive networks of base stations that connect the users through frequency (RF) signals. Over the last decade, there has been an outstanding deal of concern about possible health consequences caused by human exposure to RF generally and radiations from base stations especially.¹ measures personal exposure to radiofrequency electromagnetic fields during a swiss population sample demonstrated that the quality exposure contribution from the mobile tower has relevance for cumulative long-term whole-body exposure to radiofrequency electromagnetic fields. However, needless to say, it's of minor importance for cumulative exposure to the very best of normal mobile users.⁴ Telephone technology has several advantages and has grown rapidly. Presently 80 crores telephone users and around 4.5 lakhs telephone towers installed to supply the communication facilities in India. The number has risen remarkably because of the discounted price of the cell phones and its portability, without recognizing its faults. "For the succeeding five years, cellphone towers are demanded to be constructed at 3 percent CAGR and thus the total number of towers is forecasted to grow to quite 511,000 by the financial year 2020, of which 30,000 towers are supposed to be only providing data sites," Deloitte India statement said. The report Indian Tower Industry: the end of the day is Data estimates that there are about 400,000 mobile towers which include

only 700 standalone 3G and 4G towers. Rowley and Joyner (2012) gathered together the tower electromagnetic field (EMF) radiation data from measurement operations in 21 countries throughout the globe over a couple of years. The database of over 173,000 individual data points shows that the worldwide average exposure level from towers is as low as 0.73 mill watt per square meter, which is over 5,000 times below the WHO endorsed radiation norm for mobile towers for the frequency range considered 4 watts per square meter at 800 MHz.⁴ The bulk of those towers are positioned near the domestic and office structures to supply trustworthy mobile coverage to the users. A mobile tower and its transmitting power are designed in such a way that it covers a distance of a minimum of a couple of kilometers, implying that mobile at that distance should be ready to transmit and receive enough signal for a correct communication. A building situated at 10's of meters from the tower will receive 10,000 times stronger signals than required for mobile communication. In cities like Mumbai, Delhi, Bangalore, etc, many folks reside within these high radiation zones. Not all standards and guidelines throughout the world have recommended equivalent limits for exposure. As an example, some published exposure limits in Russia and a few eastern European countries are generally more restrictive than existing or proposed recommendations for exposure developed in North America and other parts of Europe.⁴ The utilization of cell phones is increasing immensely day-by-day but most of the people (who use the cellular phone) don't skill cell phones impact human health. it's almost clear from the research that the radiation from the phone is liable for many diseases quite a brain tumor, headaches, STM loss, differing types of heart diseases, etc, within the presence of varied RF sources, including telephone handsets and broadcast antennas which contribute to the general environmental exposure have become a prominent concern about the security of this new technology and also as human health.⁵

Cell tower radiation

GSM900 base station antenna transmits within the frequency range of 935 - 960 MHz. This waveband of twenty-five MHz is split into twenty sub-bands of 1.2 MHz, allotted to varied operators.



Effect of Ultra High Frequency Mobile Phone Radiation on Human Health

Mosa Moradi¹, Nasrollah Naghdi², Hamidreza Hemmati³, Majid Asadi-Samani⁴, Mahmoud Bahmani⁵

¹ M.Sc. of Medical Radiation, Department of Radiation Medicine, Faculty of Nuclear Engineering, Shahid Beheshti University, Tehran, Iran

² Head of Food and Drug Administration, Clinical Microbiology Research Center, Ilam University of Medical Sciences, Ilam, Iran

³ Ph.D. of Medical Radiation, Department of Radiation Medicine, Faculty of Nuclear Engineering, Shahid Beheshti University, Tehran, Iran

⁴ Ph.D. Student of Medical Immunology, Student Research Committee, Shahrood University of Medical Sciences, Shahrood, Iran

⁵ Ph.D. Student of Medical Microbiology, Lorestan University of Medical Sciences, Khorramabad, Iran

Type of article: Original

Abstract

Introduction: Public and occupational exposure to electromagnetic fields due to the growing trend of electronic devices may cause adverse effects on human health. This paper describes the risk of mutation and sexual trauma and infertility in masculine sexual cell by mobile phone radiations.

Methods: In this study, we measured the emitted dose from a radiofrequency device, such as switching high voltage at different frequencies using a scintillation detector. The switching high voltage power supply (HVPS) was built for the Single Photon Emission Computed Tomography (SPECT) system. For radiation dosimetry, we used an ALNOR scintillator that can measure gamma radiation. The simulation was performed by MATLAB software, and data from the International Commission on Non-Ionizing Radiation Protection (ICNIRP) were used to verify the simulation.

Results: We investigated the risks that result from the waves, according to a report by International Commission on Non Ionizing Radiation Protection (ICNIRP), to every organ of the body is defined by the beam and electromagnetic radiation from this electronic device on people. The results showed that the maximum personal dose over a 15-min period working at the mentioned HVPS did not exceed 0.31 μ SV/h (with an aluminum shield). So, according to other sources of radiation, continuous working time of the system should not be more than 10 hours. Finally, a characteristic curve for secure working with modules at different frequencies was reported. The RF input signal to the body for maximum penetration depth (δ) and electromagnetic energy absorption rate (SAR) of biological tissue were obtained for each tissue.

Conclusion: The results of this study and International Commission of Non Ionization Radiation Protection (ICNIRP) reports showed the people who spend more than 50 minutes a day using a cell phone could have early dementia or other thermal damage due to the burning of glucose in the brain.

Keywords: Radiofrequency, Mobile Phone, Radiobiological Effects, Mutation, ICNIRP

1. Introduction

Many people are not aware of the harmful effects of radiofrequency waves (RF) and their role in cancer and other serious risks. Scientific evidence suggests that cancer is not only linked to mobile phone radiation and that other factors also may be involved in its development. Most mobile operators use from radiofrequency waves in the range up 300 MHz to 3 GHz that can be harmful for human health (1). Many scientific studies have been done on the radiobiological effects of RF waves, and most of them have reported the rare relationship between RF exposure and

Corresponding author:

Dr. Nasrollah Naghdi, Ilam University of Medical Sciences, Ilam, Iran.

Tel: +98.2232523, Fax: +98.2232521, Email: dr.naghdi93@gmail.com

Received: January 12, 2016, Accepted: April 11, 2016, Published: May 2016

iThenticate screening: April 11, 2016, English editing: April 20, 2016, Quality control: April 26, 2016

© 2016 The Authors. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

Cell Phones and Male Infertility: A Review of Recent Innovations in Technology and Consequences

Ashok Agarwal, Aspinder Singh, Alan Hamada, Kavindra Kesari

Center for Reproductive Medicine, Cleveland Clinic, Cleveland, Ohio, United States

ABSTRACT

Cell phones have become a vital part of everyday life. However, the health risks associated with their usage are often overlooked. Recently, evidence from several studies supports a growing claim that cell phone usage may have a detrimental effect on sperm parameters leading to decreased male fertility. Nonetheless, other studies showed no conclusive link between male infertility and cell phone usage. The ambiguity of such results is attributed to the lack of a centralized assay for measuring inflicted damage caused by cell phones. Study design, ethics, and reproducibility are all aspects which must be standardized before any conclusions can be made.

Key words: male; infertility; spermatozoa; cellular phone; radiation
Int Braz J Urol. 2011; 37: 432-454

INTRODUCTION

In today's society, modern man strives to become increasingly efficient. Our fast pace lives have been the driving forces behind vast technological innovations such as the Internet, email, and most recently, the "Smartphone". Cell phones have become a vital part of our lives, and as the social pressures for optimal efficiency increase, so do the technological capabilities of cell phones.

One, often overlooked, aspect associated with recent innovations in cell phone technology, is the impact of these devices on human health, more specifically male fertility. Recent innovations in cell phone technology may have a detrimental effect on male fertility, and maybe a growing factor contributing to male infertility. This article will focus on cell phones and dissect exactly what the recent innovations in technology mean for human reproductive health and male fertility.

The essential topics of this article comprise a basic description of the cell phone technology and pathophysiological effects of the emitted radiation from cell phone devices on testicular tissues and sperm function. In addition, analysis of emerging clues from laboratory and human studies will be discussed taking into account the controversy surrounding cell phone research. Lastly, a comprehensive future look into the ensuing fertility consequences related to cell phone technology will be discussed.

General concepts of cell phone physics and biological effects

Cell phones emit radiofrequency electromagnetic waves (RF-EMW) to nearby relay base stations or antennas. Our bodies act as antennas that absorb the radiation and convert it into alternating eddy currents. The frequencies of these radio waves fall in the low frequency microwave range (800-2200 MHz), therefore, this radiation is of non-ion-

Cell phones and male infertility

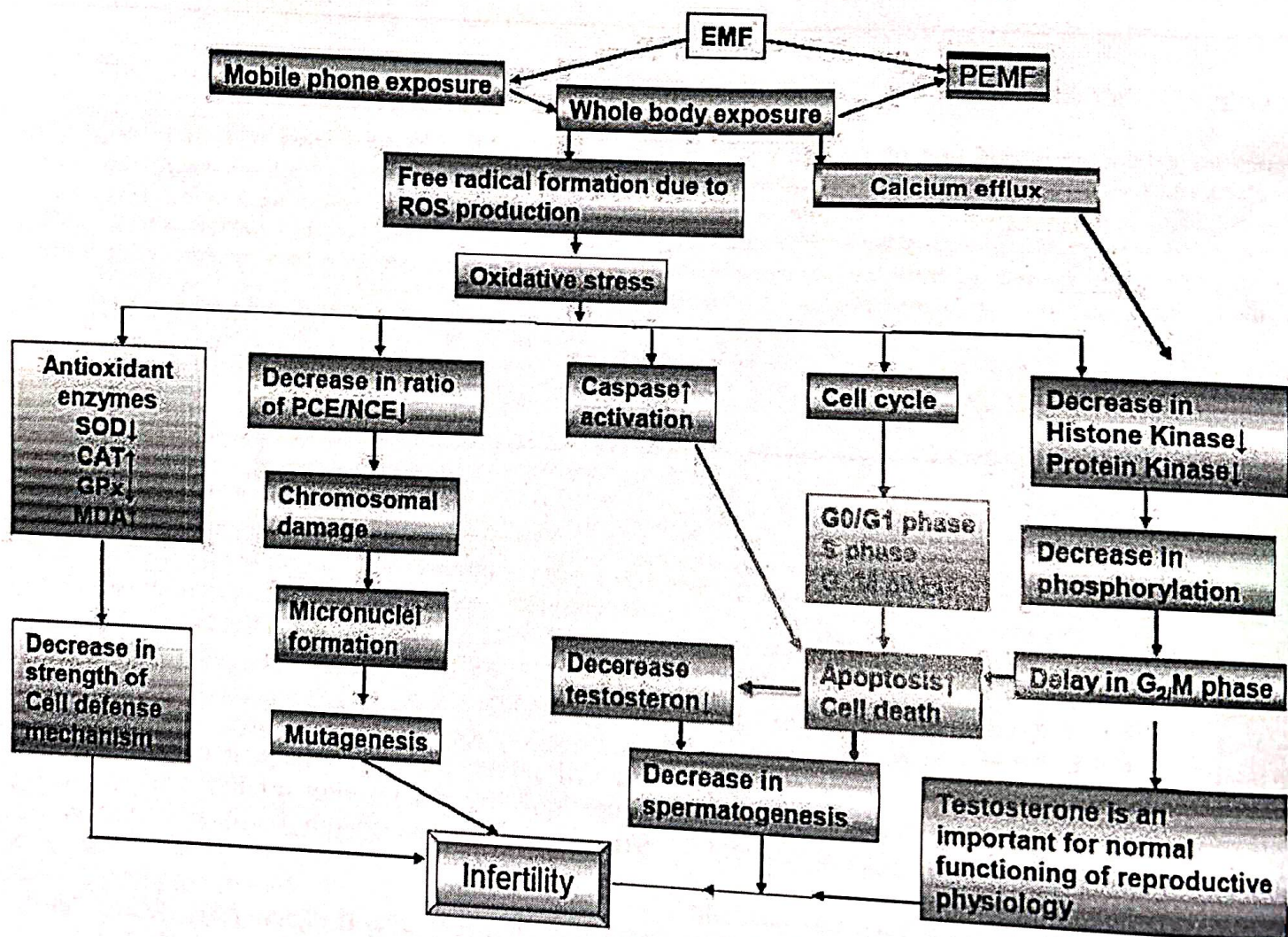
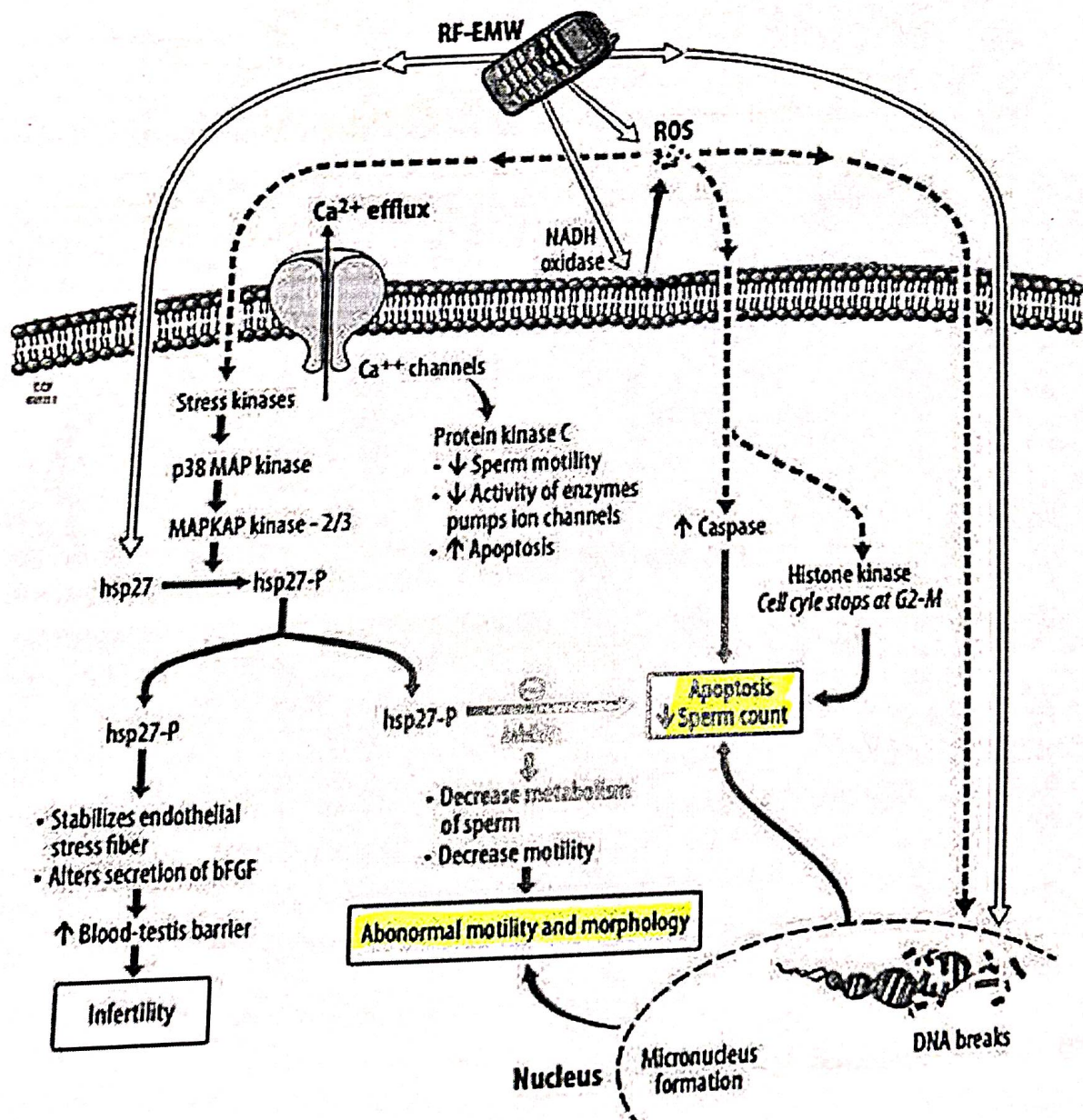


Figure 5 - Effects of RF-EMW on cellular macromolecules.



Risk of Mobile Radiation

MOBILE RADIATION



Mobile phones emit radiofrequency (RF) electromagnetic radiation, a form of non-ionizing radiation. Although it does not break DNA directly like X-rays, excessive and prolonged exposure may have potential health concerns.

HARMFUL RADIATION

HARMFUL RADIATION SIDE EFFECTS

- ▲ BRAIN TISSUE HEATING
- ▲ SLEEP DISTURBANCES
- ▲ HEADACHES & FATIGUE
- ▲ POTENTIAL CANCER RISK

HIGH RISK
FOR CHILDREN

SAFETY MEASURES:

- Use earphones or speaker mode
- Limit call duration
- Keep phone away from body
- Avoid phone use while driving

High-Risk Situations:

- Holding the phone close to the head for long calls
- Sleeping with the phone near the head
- Children using mobile phones excessively
- Using phones in low-signal areas (higher radiation emission)

Reproductive Health Concerns: Research indicates that carrying mobile phones in lower pockets may lead to decreased sperm motility and vitality due to radiation and increased groin temperature.

Metabolic Changes: Recent 2025 research has explored links between mobile radiation and increased food intake, suggesting it may influence cerebral energy homeostasis and contribute to overeating.

Sleep Disturbances: Radiation can interfere with the body's natural circadian rhythm by reducing the production of melatonin, the hormone responsible for sleep.

REPRODUCTIVE HEALTH CONCERNS



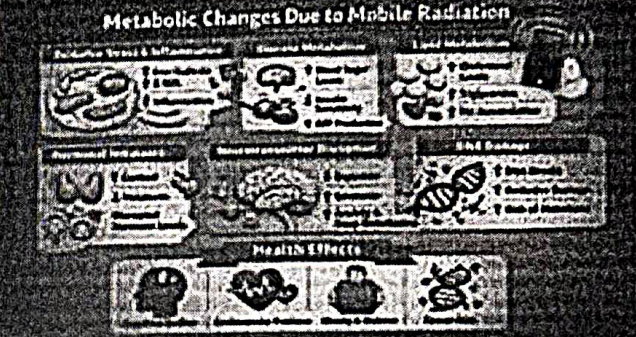
Carrying phone radiation using mobile phones for long periods increases:

- ⚠️ **Sperm damage and reduced sperm count in males**
- ⚠️ **Lower testosterone levels reported in some studies**
- ⚠️ **Potential risk of infertility due to prolonged exposure**

REPRODUCTIVE RISKS

- Avoid carrying phones in front pockets for extended periods
- Keep devices away from groin when not in use

Metabolic Changes Due to Mobile Radiation



The infographic details the following metabolic changes:

- Increased Food Intake:** Mobile radiation is linked to increased food intake, potentially leading to obesity.
- Altered Metabolism:** Radiation affects metabolic pathways, including insulin sensitivity and energy expenditure.
- DNA Damage:** Radiation can cause DNA damage, leading to mutations and potentially cancer.

HEALTH EFFECTS

- Increased food intake
- Altered metabolism
- DNA damage

SLEEP DISTURBANCES



Exposure to blue light from mobile devices increases in bedrooms making sleep difficult.

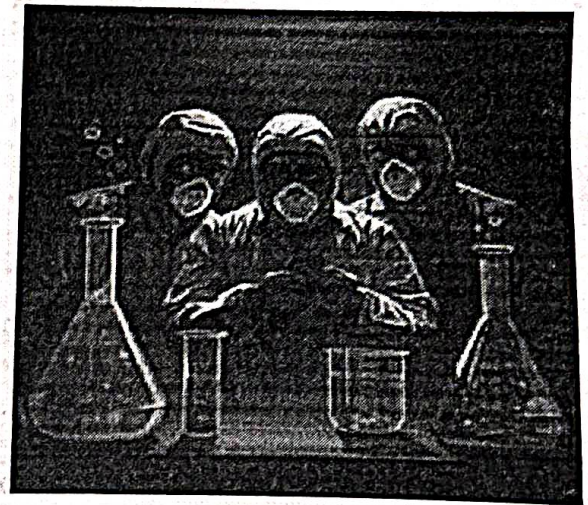
- Strokes from late night notifications can keep the mind awake
- Accumulating the used mobile phone can disrupt healthy sleep patterns

SLEEP DISRUPTION

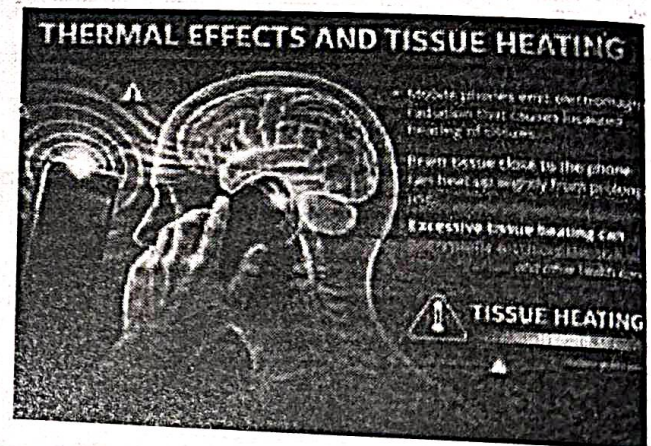
- Avoid using your phone right before bed
- Use night mode to reduce blue light exposure
- Keep your phone on airplane mode for better sleep

Key Disadvantages of Mobile Radiation

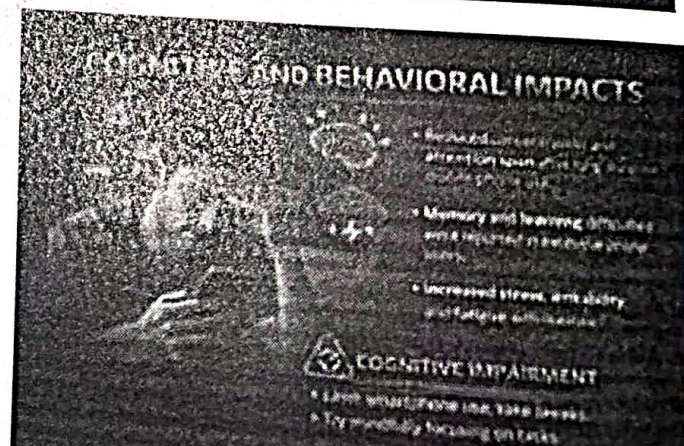
Potential Carcinogenic Risk: The International Agency for Research on Cancer (IARC) classifies radiofrequency electromagnetic fields from mobile phones as "possibly carcinogenic to humans" (Group 2B).



Thermal Effects and Tissue Heating: Prolonged use can cause a fraction of a degree increase in the temperature of the brain and facial skin. Unlike other tissues, the cornea of the eye lacks temperature regulation, making it more vulnerable to thermal damage.



Cognitive and Behavioral Impacts: Studies suggest heavy exposure may be linked to slower response times, memory loss, and in children, an increased risk of behavioral issues like ADHD.



Short Communication

A STUDY ON EFFECT OF MOBILE PHONE RADIATION ON HUMAN HEALTH

Rajdeep Mitra', Milan Mazumder, Koushik Pal¹, Subasish Jana²

ABSTRACT: A study was conducted in and around North-East Kolkata, West Bengal, India to find out the effect of Electro-Magnetic Radiation emitted by Global System for Mobile (GSM) and Code Division Multiple Access (CDMA) Mobile Phones on blood pressure, heart rate, pulse rate, respiration rate and body temperature on 20 healthy people (10 male and 10 female), age group within 21 to 60 years. In silent and calling mode, rapid and arrhythmic heart rate, rapid and irregular pulse rate were noted in 5% male in the age group of 21-40 years after 30 minutes exposure, when handset placed in ear closure to brain. Same observations were found only in 5% male after 15 minutes exposure and in 5% female & 10% male after 30 minutes exposure, when handset placed on chest closure to heart in the age group of 41-60 years.

Key words: Electro-magnetic radiation, Mobile phone, Blood pressure, Heart rate, Pulse rate, Respiration rate, Body temperature, Arrhythmia.

The development and application of devices that emit radio-frequency radiation have significantly increased the quality of life throughout the world (Ayeni *et al.*, 2011). The rapid increase in the use of mobile phones (MPs) in recent years has raised the problem of health risk connected with high-frequency electromagnetic fields, remain (Ahamed *et al.*,

2008, Saini and Pandey 2013). Electromagnetic radiofrequency emitted from MP, which was liable for causing a number of negative health effects in the form of influencing on the heart and circulatory system (Fatma *et al.*, 2011). Oliver *et al.* (2011) reported that high-frequency electromagnetic fields of MP is associated with health risks. Even electromagnetic fields which

Department of Electronics and Communication Engineering, Regent Education and Research Foundation, Barrackpore, Kolkata - 700121, West Bengal, India.

*Corresponding author. e-mail: rajdeepmitra01@gmail.com

¹ Assistant Professor, Department of Electronics and Communication Engineering, Gurunanak Institute of Technology, Kolkata, West Bengal, India.

² Medical Officer, Swastha Bhavan, Kolkata, India.

Review Article

Martin L. Pall*

Millimeter (MM) wave and microwave frequency radiation produce deeply penetrating effects: the biology and the physics

<https://doi.org/10.1515/reveh-2020-0165>

Received December 11, 2020; accepted April 28, 2021;

published online May 26, 2021

Abstract: Millimeter wave (MM-wave) electromagnetic fields (EMFs) are predicted to not produce penetrating effects in the body. The electric but not magnetic part of MM-EMFs are almost completely absorbed within the outer 1 mm of the body. Rodents are reported to have penetrating MM-wave impacts on the brain, the myocardium, liver, kidney and bone marrow. MM-waves produce electromagnetic sensitivity-like changes in rodent, frog and skate tissues. In humans, MM-waves have penetrating effects including impacts on the brain, producing EEG changes and other neurological/neuropsychiatric changes, increases in apparent electromagnetic hypersensitivity and produce changes on ulcers and cardiac activity. This review focuses on several issues required to understand penetrating effects of MM-waves and microwaves: 1. Electronically generated EMFs are coherent, producing much higher electrical and magnetic forces than do natural incoherent EMFs. 2. The fixed relationship between electrical and magnetic fields found in EMFs in a vacuum or highly permeable medium such as air, predicted by Maxwell's equations, breaks down in other materials. Specifically, MM-wave electrical fields are almost completely absorbed in the outer 1 mm of the body due to the high dielectric constant of biological aqueous phases. However, the magnetic fields are very highly penetrating. 3. Time-varying magnetic fields have central roles in producing highly penetrating effects. The primary mechanism of EMF action is voltage-gated calcium channel (VGCC) activation with the EMFs acting via their forces on the voltage sensor, rather than by depolarization of the plasma membrane. Two distinct mechanisms, an indirect and a direct mechanism, are consistent with and predicted by the

physics, to explain penetrating MM-wave VGCC activation via the voltage sensor. Time-varying coherent magnetic fields, as predicted by the Maxwell-Faraday version of Faraday's law of induction, can put forces on ions dissolved in aqueous phases deep within the body, regenerating coherent electric fields which activate the VGCC voltage sensor. In addition, time-varying magnetic fields can directly put forces on the 20 charges in the VGCC voltage sensor. There are three very important findings here which are rarely recognized in the EMF scientific literature: coherence of electronically generated EMFs; the key role of time-varying magnetic fields in generating highly penetrating effects; the key role of both modulating and pure EMF pulses in greatly increasing very short term high level time-variation of magnetic and electric fields. It is probable that genuine safety guidelines must keep nanosecond timescale-variation of coherent electric and magnetic fields below some maximum level in order to produce genuine safety. These findings have important implications with regard to 5G radiation.

Keywords: 5G modulating pulses; coherent electronically generated EMFs; EMF pathophysiological and therapeutic effects; increased $[Ca^{2+}]_i$ and calcium signaling; modulating pulses and biological EMF effects; penetrating effects via time-varying magnetic field penetration.

Introduction

Electronically generated electromagnetic fields (EMFs) are highly coherent, being generated at specific frequencies, with specific vector direction, with a specific phase and specific polarity. The special physics properties of such coherent EMFs have been discussed [1–5]. Similarly, biological impacts of coherent EMFs have also been discussed [6–10]. Such coherent EMFs generate much stronger electrical forces and magnetic forces than do natural incoherent EMFs. Most but not all natural EMFs are incoherent. The much stronger forces produced by electronically generated EMFs are of great importance with regard to EMF

*Corresponding author: Martin L. Pall, Professor Emeritus, Biochemistry and Basic Medical Sciences, Washington State University, Portland, OR 97232-3312, USA, E-mail: martin_pall@wsu.edu. <https://orcid.org/0000-0002-8784-8287>

Open Access. © 2021 Martin L. Pall, published by De Gruyter. This work is licensed under the Creative Commons Attribution License.

iScience

Review
Interacti
radiation

Lingyu Liu,^{1,5} Bi

SUMMARY

Even though the past several actions between duce and sum have investiga biochemical re electromagnet are not propo commonly use far fewer stu EM environm quite restrict

INTRODUCTION

Biological syste forms of energ responses of th have been po as the sensitv remains to be knowingly se isolated from have been c

STUDIES

Overview

The level of the techn certain o 300 kHz a importan respond clinical s and tre The cated e sympto

¹Beijing Science
²Brain F
³Westl
⁴Key L
⁵Shilong
⁶These
⁷Corre
<https://>

Review

Interactions between electromagnetic radiation and biological systems

Lingyu Liu,^{1,5} Bing Huang,^{2,5} Yingxian Lu,^{3,4,5,*} Yanyu Zhao,^{3,4} Xiaping Tang,^{3,4} and Yigong Shi^{1,3,4,*}

SUMMARY

Even though the bioeffects of electromagnetic radiation (EMR) have been extensively investigated during the past several decades, our understandings of the bioeffects of EMR and the mechanisms of the interactions between the biological systems and the EMRs are still far from satisfactory. In this article, we introduce and summarize the consensus, controversy, limitations, and unsolved issues. The published works have investigated the EMR effects on different biological systems including humans, animals, cells, and biochemical reactions. Alternative methodologies also include dielectric spectroscopy, detection of electromagnetic emissions, and theoretical predictions. In many studies, the thermal effects of the EMR are not properly controlled or considered. The frequency of the EMR investigated is limited to the commonly used bands, particularly the frequencies of the power line and the wireless communications; far fewer studies were performed for other EMR frequencies. In addition, the bioeffects of the complex EM environment were rarely discussed. In summary, our understanding of the bioeffects of the EMR is quite restrictive and further investigations are needed to answer the unsolved questions.

INTRODUCTION

Biological systems have developed clever strategies to sense and to make use of the matters and energy in the environment. Among different forms of energy is electromagnetic radiation (EMR), which is pervasive in the earth's atmosphere since before the inception of life. The bio-responses of the visible frequency bands are obvious. In contrast, the bio-responses to the nonradiative EMR just next to the visible range have been poorly understood. But it is intuitively irrational if the biological systems have selected only an extremely narrow band of frequency as the sensitive range. Thus, there might be different forms of bio-responses to the EMR including radio frequency to be discovered, which remains to be an interesting research topic. One of the difficulties of discovering a new bioeffect of the EMR is the lack of hint: people cannot knowingly sense the existence of EMR surrounding them. Another problem is that the possible bioeffects of the EMR are difficult to be isolated from a complex bioeffect caused by other factors accompanied with the EMR, such as heat. Despite such difficulties, many studies have been carried out to examine the bio-responses to EMR using different approaches, as summarized in Scheme 1.

STUDIES OF IMPACTS OF EMR ON HUMANS

Overview of the epidemiological investigations and experiments on humans

The level of nonradiative EMR in the environment of our daily life has been drastically increased since the 1950s with the rapid development of the techniques of wireless communication. The highest power flux density is over 10^{18} times higher than the natural level^{1–3} and people of certain occupations are exposed to EMR of power density even higher, especially the radio frequency EMR (RF-EMR) in the range between 300 kHz and 300 GHz. Epidemiological studies of humans, especially those with occupational exposure to high levels of EMR, can provide important evidence of the risks of the exposure to EMR and indicate potential reporter systems that could be affected by the EMR. The corresponding reporting systems mainly include physiological and pathological effects, diseases from epidemiological retrospective studies, clinical symptoms, and diseases after daily or occupational exposure to EMR. Guidelines are written accordingly for the prevention, diagnosis, and treatment of EMR-related health problems and illnesses.^{4,5}

The epidemiological investigations of the impact of EMR on humans should be carefully designed to integrate the variables in the complicated electromagnetic environment. Among them, questionnaire surveys and case reports are superior in providing information of self-report symptoms induced by EMR exposure; while double-blind cohort studies are typically used for analysis of pathogenesis and impact factors.^{4,5}

¹Beijing Advanced Innovation Center for Structural Biology & Frontier Research Center for Biological Structure, Tsinghua-Peking Joint Center for Life Sciences, School of Life Sciences, Tsinghua University, Beijing 100084, China

²Brain Function and Disease Laboratory, Department of Pharmacology, Shantou University Medical College, 22 Xin-Ling Road, Shantou 515041, China

³Westlake Laboratory of Life Sciences and Biomedicine, Xihu District, Hangzhou 310024, Zhejiang Province, China

⁴Key Laboratory of Structural Biology of Zhejiang Province, School of Life Sciences, Westlake University; Institute of Biology, Westlake Institute for Advanced Study, 18 Shilongshan Road, Hangzhou 310024, Zhejiang Province, China

⁵These authors contributed equally

*Correspondence: luyingxian@westlake.edu.cn (Y.L.), syg@westlake.edu.cn (Y.S.)

<https://doi.org/10.1016/j.isci.2024.109201>



Review

Microwave Radiation and the Brain: Mechanisms, Current Status, and Future Prospects

Sohail Mumtaz ^{1,2,*}, Jule Nahushkumar Rana ^{2,3,†}, Eun Ha Choi ^{1,2,3,*} and Ihn Han ^{2,3,4,†}

- ¹ Department of Electrical and Biological Physics, Kwangwoon University, Seoul 01897, Korea
 - ² Plasma Bioscience Research Center (PBRC), Applied Plasma Medicine Center, Kwangwoon University, Seoul 01897, Korea
 - ³ Department of Plasma Bio-Display, Kwangwoon University, Seoul 01897, Korea
 - ⁴ Correspondence: ehchoi@kw.ac.kr (E.H.C.); hanihn@kw.ac.kr (I.H.); Tel.: +82-2-940-5666 (I.H.); Fax: +82-2-940-5664 (I.H.)
- † These authors contributed equally to this work.

Abstract: Modern humanity wades daily through various radiations, resulting in frequent exposure and causing potentially important biological effects. Among them, the brain is the organ most sensitive to electromagnetic radiation (EMR) exposure. Despite numerous correlated studies, critical unknowns surround the different parameters used, including operational frequency, power density (i.e., energy dose), and irradiation time that could permit reproducibility and comparability between analyses. Furthermore, the interactions of EMR with biological systems and its precise mechanisms remain poorly characterized. In this review, recent approaches examining the effects of microwave radiations on the brain, specifically learning and memory capabilities, as well as the mechanism of brain dysfunction with exposure as reported in the literature, are analyzed and interpreted to provide prospective views for future research directed at this important and novel medical technology for developing preventive and therapeutic strategies on brain degeneration caused by microwave radiation. Additionally, the interactions of microwaves with biological systems and possible mechanisms are presented in this review. Treatment with natural products and safe techniques to reduce harm to organs have become essential components of daily life, and some promising techniques to treat cancers and their radioprotective effects are summarized as well. This review can serve as a platform for researchers to understand the mechanism and interactions of microwave radiation with biological systems, the present scenario, and prospects for future studies on the effect of microwaves on the brain.

Keywords: microwaves biological effects; cellular effects; radiations and brain; nonthermal plasma; flavonoids; Alzheimer's disease; tissue damage; human health

1. Introduction

Microwaves are recognized as nonionizing radiation, with a broad frequency spectrum ranging from 300 MHz to 300 GHz. Specifically, the bands from 300 MHz to 3 GHz are UHF (ultra-high-frequency), 3–30 GHz are SHF (super-high-frequency), and those from 30 to 300 GHz are EHF (extremely high-frequency). Additionally, microwaves that exceed a peak power of 100 MW with an operation frequency lying between 1 to 300 GHz are generally considered high-power microwaves (HPMs). HPMs are commonly employed in modern technologies, and have been proven to be indispensable in our lives, with uses in the commercial, military, and medical fields [1–4]. Pulse microwave sources and non-pulse microwave sources are the two types of HPM sources available. A microwave source with a rising edge of sub-nanoseconds or picoseconds is referred to as a pulsed microwave source. A primary drive (explosive or pulse generation system), a pulse compression system, a microwave generation source, and an antenna are all included. Through low-speed storage and fast release of energy, pulse sources typically transform energy into short-pulse EMR.



Citation: Mumtaz, S.; Rana, J.N.; Choi, E.H.; Han, I. Microwave Radiation and the Brain: Mechanisms, Current Status, and Future Prospects. *Int. J. Mol. Sci.* **2022**, *23*, 9288. <https://doi.org/10.3390/ijms23169288>

Academic Editor: Ali Gorji

Received: 6 July 2022

Accepted: 16 August 2022

Published: 18 August 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

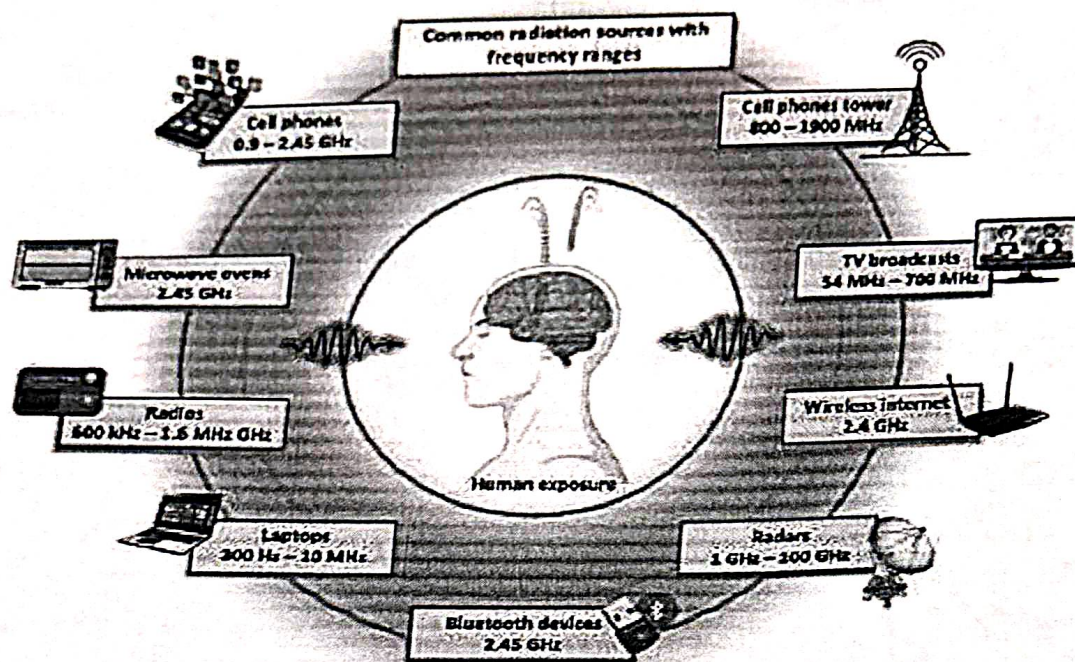
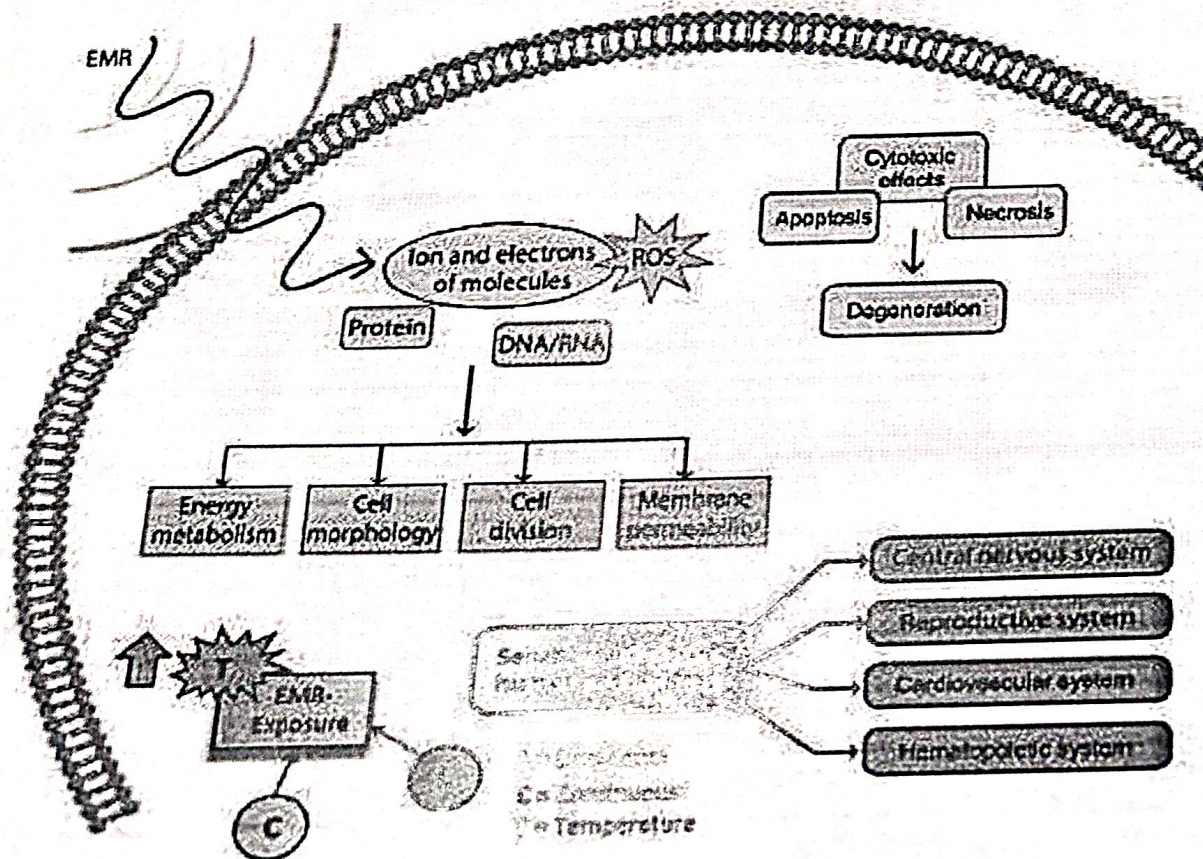


Figure 1. Depiction of daily commercial and household radiation sources with corresponding operational frequency ranges.



as microwave radiation poses higher possibilities of different health risks with greater exposure frequencies in both humans and animals.

