

Health Effects of Fifth-Generation Technologies

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Abstract

The advancement of telecommunication technology is vital for our wireless connectivity and networking across the world, but not at the expense of the lives of other organisms because their extinction follows us. This review article highlighted the various communication systems and technologies implemented and their implications. The relevant keywords used for this review, including fifth generation (5G), electromagnetic radiation (EMR), telephone tower, 5G impacts on lives, 5G impacts on human health, animals, and birds, were used for inclusive search on trustworthy citation databases listed in Scopus, PubMed, Web of Science, and Google Scholar from 1993 to 2022. The findings revealed that the radiations range between radio frequency and electromagnetic frequency is causing detrimental effects on different species including their fertility and fetus development. Experts reported that birds use the earth's EMR to navigate in their flight, but when they are exposed to weak or microwave radiation from the telecommunication towers, they deviate from their path, confused, and even die from telephone tower collisions. The new movement in protecting the bird population from EMR is creating an awareness of "air as a habitat" for birds, and research reports show that it is experimentally proven, that such radiations affect the birds' lives in many ways. Authors believe that these critical surveillance data would create awareness among the readers and researchers about the consequences to human health due to the extensive use of new generation telecommunication and networking technologies. The World Health Organization mentioned the harmful effects of EMR in their report. It shows that a diffuse collection of symptoms such as headaches, anxiety, suicide and depression, nausea, fatigue, and loss of libido may be caused due to low levels of exposure to EMR at home.

Keywords: Electromagnetic radiation, fifth generation, impacts on lives, review, wireless communication

INTRODUCTION

We, humans, have always tried our level best to make our lives fast and easy by not thinking about the side effects of any adopted technology. For example, the attempts made to advance tele-connectivity and networking on this planet have resulted in the disconnection and muddle of many living beings such as insects, bees, birds, and other lives. Nevertheless, we are not worried about almost everything including the development of telecommunications from the first generation (1G) to 4G and now fifth generation (5G), the rapid revolutionary communication and networking technology on the way, which has led to negative impacts on numerous living beings including humans. In the days of implementation of 2G, many birds were harmed, 3G led to the loss of their lives, the 4G ruined many lives of bird species, and many species became endangered and extinct as well. Now, the Indian government permitted the testing of 5G in India and implemented it. This reminds us of Sir Albert Einstein's words, "I fear the day that technology will surpass

our human interaction. The world will have a generation of idiots." These words were spoken several decades ago, but now, we are undergoing many threats to various lives in our everyday life deprived of taking any measure.^[1] For example, although we are aware that electromagnetic radiation (EMR) harm living organisms, the various governments across the globe permit to use by setting the minimum standards for exposure for animals, public and occupational public exposures. The standards and guidelines recommend that the general population shall have a threshold radio frequency (RF) exposure of specific absorption rate (SAR) is 0.08 W/kg, while for animals, it is 0.4 W/kg at high ambient temperatures.^[2]

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The 5-hydroxytryptamine (5-HT) “serotonin” is vital for the regulation of physiological functions and has been reported as the indicators of brain injury induced by EMR.^[3] Lower electromagnetic fields like nonthermal microwave may cause an extensive neuropsychiatric illness including depression.^[4] In 2020, the World Health Organization (WHO) updated its International Commission on NonIonizing Radiation Protection (ICNIRP) guidelines for limiting exposure to larger RF Electromagnetic Fields (RF EMF) concerning health effects from RF EMF exposure. Experimental research inferred that EMR triggers the excitatory glutamate, the neurotransmitters in the brain of Wistar rats.^[5] A recent report shows that the membrane of living cells is an important target of electromagnetic frequency (EMF), even <3 GHz pulsed microwave radiation damages the membranes in the hippocampal neurons of Wistar rats under *in vitro* condition and might lead to neurotransmitter deviations in the brain due to calcium efflux.^[6] Based on the various impacts reported on the advancements in telecommunication and networking technologies, this study intended to review the health effects of 5G technologies on humans and other lives.

METHODS

The present review was conducted based on the evaluation of research reports made by several eminent scientists and reputed organizations from 1993 and 2022 and focused on implications of the advancement of networking and telecommunication technologies, the impact of 5G on various lives, and 5G impacts on human health, animals, and birds, and the possible solutions were also provided to overcome the challenges. The scientific works of literature and data associated with the issues were collected and compiled from the authentic scientific databases, namely, Google Scholar, Scopus, PubMed, and Web of Science, and annual reports of various multinational organizations like the WHO, International Agency for Research on Cancer (IARC), National Institute of Environmental Health Sciences, British Trust for Ornithology, etc. We have chosen and used various combinations of the keywords like 5G, EMR, telephone tower, 5G impacts on lives, etc.

RESULTS AND DISCUSSION

Advancements in networking and telecommunication technologies

There is a lot of excitement in the air as several telecommunication companies are coming forward with their plans to adopt 5G.^[7] Because, 4G has astonished the Wi-Fi user’s connectivity in the world, and now, 5G will add 50 folds higher speed than 4G which will make digital communication near seamless as it is going to make things faster in the field of communication, Internet of things (IoT), etc., at the cost of lives of birds, including dogs, other animals, and human. 5G is the 5G in cellular networking technology, connect networks and devices faster even in the field of smart homes, driverless car, etc., and the technique used to increase the speed is called multiple-input multiple-output technologies which can connect around one million devices/sq. km [Table 1].^[8]

Fifth-generation technology

It is a new standard for cellular networks started by phone companies throughout the world in 2019, the strategic replacement for the 4G networks. 5G service area is divided into small geographical areas called cells; the 5G wireless devices in a cell are linked to the Internet and telephone network by radio waves through a local antenna in the cell. The key benefit is that they have a superior bandwidth and help quicker download speeds up to 10 Gb/S.^[14] As there is an improved bandwidth, it is anticipated that the novel networks for cellular networks, laptops, and desktops, challenging the present broadband Internet, will have probable new applications in the IoT and machine-to-machine connections as well. If the 4G cellphones are not compatible with 5G networks and require new 5G Wi-Fi-enabled devices, then what about the already existing 4G devices? Hence, there will be millions of people who abolish the inoperable 4G mobile phones and gadgets that cause a huge electronic waste.

Application of fifth-generation technology in sustainable agriculture

5G technology promotes the development of modern agriculture in the direction of intelligence and precision.

Table 1: Summary of telecommunication technology generations, their features, benefits, and their impacts

G	History	Features and benefits	Frequency range	Impacts	Reference
1G	Nippon Telegraph and Telephone in 1979 in Tokyo, Japan	First wireless communication and voice only	150-900 MHz	Lesions on skin and internal tissues of animal tissues	[9]
2G	GSM in 1991 in Finland	Multiple users on a single channel, voice, and data	1.8 GHz	Damage to embryos of bird’s eggs	[10]
3G	NTT DoCoMo in 2001 at Japan	Faster connectivity and internet access	1.6-2.0 GHz	Damage to embryos of eggs of different species and various structural changes including DNA damage	[11]
4G	First 4G LTE Rogers Communications in 2011 at Canada	Wider coverage, fast data transfer	1.8-2.6 GHz	Hearing loss, effect on the unborn child in the womb which may lead to miscarriage, etc.	[12]
5G	KT, LG Uplus, and SK Telecom, the South Korean telecom providers in 2019 at South Korea	1Gb/s is possible for wireless communication, advanced security	24.45-28.35 GHz	Effect on human health, effect on birds, and all other organisms	[13]

GSM: Global System for Mobile Communications, LTE: Long-term evolution

It plays a very important role in both the research and development of agricultural products and the planting and production of agricultural products. 5G network technology has a faster information dissemination rate and higher quality of information dissemination when compared to 4G technology, which can effectively solve the problems existing in the original wireless transmission. When combined with the agricultural IoT, 5G technology can identify and change the direction of agricultural planting and rural economic development. It not only improves the efficiency and quality of agricultural planting but also contributes to the sustainable and stable development of the rural economy. 5G offers a great potential for agriculture. Many farms, whose access to fiber optics is too expensive, will get a broadband internet connection through 5G. Machines and installations in stables and on fields at any location can be integrated into a farm network. The beauty of 5G is that machines stay connected in the farm network, even if they work out of the farm. A wide range of new technologies are being developed, such as irrigation control, weed regulation, cow sensors, and autonomous vehicles; all of which benefit from fast data transmission. These technologies will be important to make agricultural production more efficient and sustainable to address the major current challenges.^[15]

Effects of electromagnetic radiation on all the living organisms

In mobiles, spots surrounding the antenna captivate the energy and change it to heat, and the semiconductor diodes are used as antennas, so the mobile itself acts as an antenna for receiving signals. When mobile phones are kept close to the human body, the signal transmission process emits EMR. When this EMR passes through a human body, it thermally affects the human body by heating up [Figure 1]. Technically guaranteed impacts to live organisms on the exposure to RF electromagnetic radiation heating, but fewer exposure limits, this is prevented and when the whole body is exposed the thermal effects are negligible. When the mobile exposure is local like head, trousers, and chest pockets in the proximity

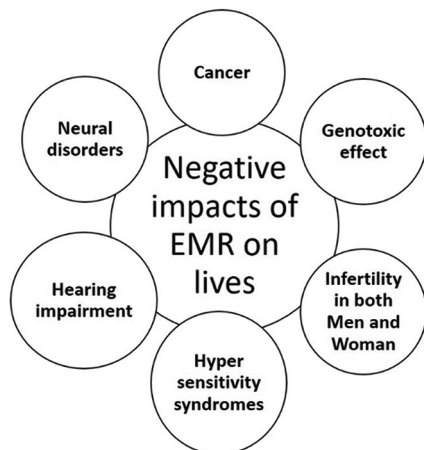


Figure 1: Impact of mobile tower electromagnetic radiation^[16]

of the antenna, it leads to an increase in temperature $<1^{\circ}\text{C}$, primarily in the skin, brain, and ear, and in the ear canal, the temperature rise is on the increment of 0.1°C .^[17] A general confusion by the common man for the heat observation at the ear pinna due to a prolonged telephonic discussion is due to radio frequency electromagnetic force, and the research reports have revealed that radio frequency electromagnetic force is accountable for a minor increment in temperature. The major heat is produced by the phone's battery and electric circuits, when it is in use as well as in low-charge mode or exposure to bright sunlight inside a locked car, etc.^[18] The thermal effects are also caused due to over and continuous usage of gadgets and extended conversations on mobile phones by keeping them close to the body.^[19]

The research reports show that 5-HT, a "serotonin," is enormously produced in the gastrointestinal tract; only a small percentage is formed inside the nervous system and mainly dispersed in the pineal gland and hypothalamus, especially in the cerebral cortex and neural synapses. It plays an important role in the regulation of physiological functions such as mood, feeding, cognition, memory, pain, sleep, and body temperature maintenance. 5-HTs have been reported as the indicators of brain injury induced by EMR.^[3]

People living in the surroundings of mobile towers are the most threatened among the population. Health-care researchers have reported that RF emitted by the mobile towers is the main cause of some diseases like infant leukemia, brain tumors, toxic effects, neurological diseases, etc. Mainly in certain children, it may cause immune system deregulation and allergic and inflammatory responses.^[20] Exposure to microwave frequency EMFs may lead to neuropsychiatric-related illnesses with depression, and they are also called as microwave syndrome. The nonthermal microwave/lower EMFs work through voltage-gated calcium channel (VGCC) activation; VGCCs rise in very high densities throughout the nervous system and have near widespread roles in the release of neurotransmitters and neuroendocrine hormones and impacts on the brain. Disproportionate VGCC activity has been shown to have roles in producing neuropsychiatric changes in humans, and short wave, radio station, and occupational and digital TV antenna exposures may cause similar neuropsychiatric effects, and the more commonly reported changes are sleep disturbance/insomnia, headache, depression/depressive symptoms, fatigue/tiredness, dysesthesia, concentration/attention dysfunction, memory changes, dizziness, irritability, loss of appetite/body weight, restlessness/anxiety, nausea, skin burning/tingling/dermographism, and EEG changes.^[4]

In women, it may cause infertility and some cardiovascular effects. Sleep disruption, insomnia, anxiety, unhappiness, distress, prickliness, vomiting, vertigo, and hunger loss is also some of the major diseases caused to teenagers due to RF. Impacts of nonthermal radiofrequency on rat mammalian blood-brain barrier, in which a valve-like structure that controls the blood passing through the brain of the rats, is

caused due to RF-induced heat emission. Some reports show that cows farmed near mobile towers for two consecutive years have reduced milk production as well as increased health, behavioral problems, stillbirths, and irregularities. Studies on bees in England found that they refused to return to their beehives where there were digital enhanced cordless telecommunications phone stations.^[21-23]

EMR produced by mobile phones and telephone towers distresses the flora and fauna. Movements and habitats of birds, bees, sparrows, and pigeons close to telephone towers have become unusual. For the birds, the surface area is greater than their mass compared to humans, and hence, they captivate additional radiation. Meanwhile, the liquid composition in the birds is lesser because they have less body weight so they get warmed up sooner. Therefore, the bird's brain gets heated up the navigational aids might be disrupted as the nerve cells slip their response and break working effectively [Figure 2]. The reproductive potency of certain insects has lessened by 60% due to the radiation effects (900 MHz).^[24] The short-term effects are associated with the electrical activity of the brain, cognitive function, blood pressure, and heart rate. However, the consequences are headache, tinnitus, fatigue, dizziness, muscle problem, dysesthesia of the scalp, sensations of heat, blackout, and epidemiological and visual symptoms including cancer and brain tumors.^[25]

“Air as a habitat” and electromagnetic radiation affects

More people are using Wi-Fi-enabled devices, and nowadays, small kids own Internet-aided mobiles, and this affects wildlife too. The concept of “air as a habitat” is also taking a new form for birds and insects.^[26] The main medium for the transmission of signals is air; besides, the air is also the habitat of many bird species; however, due to the exposure to signal radiation, bird species are getting affected both physically and mentally. In Belgium, minor EMR from mobile phone base stations has impacted the house sparrows’ lives. The study was conducted by examining six flocks of birds, which are living near Global System for Mobile Communication stations, varied by certain distances. House sparrow population was significantly affected by both the 900 and 1800 MHz frequency bands, and in

UK, urban birds and sparrows populations have also been reduced.^[27]

In England, the sparrow population has decreased from 24 million to <14 million in the past three decades. The more unforeseen decline (75%) was between 1994 and 2002. A certain sparrow species were included in the endangered species of the United Kingdom, and many different types of sparrows have been missed recently around Brussels and Dublin. Of the 14, three species have disappeared (migrated or may have been extinct), four are in deterioration, and seven are unchanging, just in the span of 10 years from 1997 to 2007, and several species of birds (*Pica pica*) were detected with many diseases in their different body parts.^[18,28-30]

EMF and its negative impacts

The recent reports suggest that the exposure to electromagnetic frequency affects the role of the immune system,^[31,32] and found that stressed birds are susceptible to all pathogenic attacks.^[33] The normal life of young birds is also affected due to the exposure to electromagnetic fields.^[34,35] Even the reproductive success in birds is being affected due to EMF and microwaves. EMF exposure affected the reproductive success and hamper hatching success. Even though some species (*Falco sparverius*) have resistance to EMF, their eggs are unable to resist the power, so affected; only a few eggs are resisting the effect and are being hatched.^[36] The radiofrequency and microwaves from mobile phones can cause DNA damage. More exposure to radiofrequency may lead to an increase in cytological abnormalities (cell disorders) which infer enduring harmful effects on the genetic material causing birth defects and cancer.^[37] In chicken embryos, lower weight, mortality rate, and physical aberrations were reported due to pulsed magnetic field exposure.^[38-42] The ranges such as 0–300 Hz and 10 MHz–300 GHz will change the perviousness of the blood–brain barrier.^[43,44]

Birds and the magnetic field of earth

The earth’s magnetic field is vital for bird navigation, and an experiment by Emlen funnel demonstrated how birds react to electromagnetic waves.^[45] This reveals about a seed-eating songbird (related to the species “finch”) exposed to urban EMR loses its bearing. They become sternly confused by the radiation from mobile phone towers and start deviating from their destination point. Birds use the earth’s EMR s to navigate during their flight time, confused by weak electromagnetic fields, and these innumerable migrant birds died.^[46]

Effects of EMF on vertebrates

The electromagnetic frequency declines the semen tally in addition to motility and biological damage. Cellular phone waves might cause oxidative stress within the animal body.^[47,48] The correlation study between the exposure to electromagnetic frequency radiations and deoxyribonucleic acid and bodily injury in lymphocytes of mobile phone users was reported.^[49] Radiofrequency radiation alters the transport of cations through ion channels placed in the biological

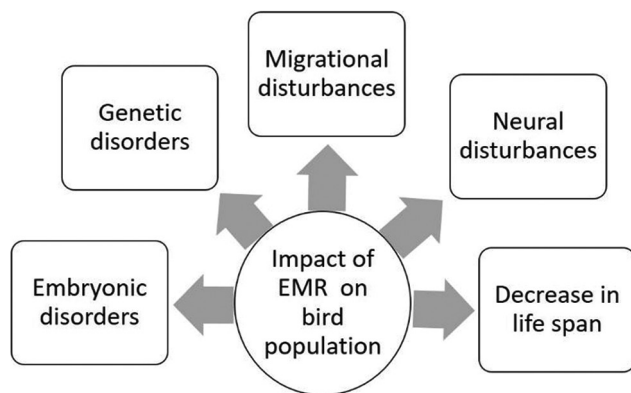


Figure 2: Negative impacts of EMR on bird population. EMR: Electromagnetic radiation

membrane and can influence membrane potential and nervous signal transduction. Radiation at 1.5 Giga cycle pulsing for 16 ms at 0.3 mW/cm² power density for a month (30⁷/day) caused anxiety in rabbits.^[38,50]

A drop in rodent birth was also reported due to acquaintance with the radio frequencies, and certain mice became sterile sooner under 1.053 W/cm² than the one exposed to 0.168W/cm².^[51] Pregnant women under magnetic fields above 2.0 mG have exhibited fetus abnormalities and abortion risks. Fetal and neonatal heart rate was significantly increased (<160 beats), when the pregnant women were exposed to mobile phones, as well as cardiac output was decreased.^[52] The WHO/IARC has classified radiofrequency electromagnetic fields associated with wireless phone use as possible cause for malignant type of brain cancer.^[53] People who use mobile phones on one side of the head had suffered from brain tumors, and radio frequency electromagnetic frequency also declines sperm count and motility.^[54] Radio station at Skrunda, Latvia, caused neuromuscular apparatus-based health problems in children exposed to the radiation.^[55] In 2015, the European Commission's Scientific Committee on Emerging and Newly Identified Health Risks reviewed that the epidemiologic studies on radiofrequency exposure has the possibility of an association with acoustic neuroma.^[56-58] Recently, the WHO updated its ICNIRP guidelines for limiting exposure to larger RF EMF ranging from 100 KHz (kilohertz) to 300 GH (gigahertz) based on the evaluation over many years of peer-reviewed scientific literature concerning the health effects from RF EMF exposure, and the guidelines cover many applications such as 5G technologies, WiFi, Bluetooth, mobile phones, and base stations.^[59]

Authors recommendations

Telecommunication technology has brought a lot of ecological imbalances and irreversible health problems including the loss and risk of extinction of many species. Taking into consideration, the future damages which can be triggered by 5G, we have to move from the Wi-Fi mode of connectivity to cables between telephone towers which may reduce negative impacts on lives. We must reduce our Internet usage time like we save our natural resources. Why cannot we continue with 4G to diminish the ecological damages further as we have lost many species during the shift from 1G to 4G? Because 5G might even pose a threat to human lives in many ways including dumping huge electronic wastes from scrapped mobile phones, gadgets, etc., for 5G network and due to the crazy consumerism. An alternate line that works on established electromagnet theories must be implemented and modern procedures for 5G connectivity that does not involve wires or RFs should be adopted. The next eco-friendly and life-saving available technique is quantum communication. This will yield many limitless bandwidth channels for any individual in a very quicker connectivity than the speed of light and does not require cables or waves.^[60]

CONCLUSION

5G, the current emerging networking, and communication systems have more disadvantages than its merits as it has become deadly to many lives and at the planetary scale, based on many authentic reports. The human technological inventions that help human never be lethal to any lives on this planet as it leads to the extinction of many species including human after unprecedented illness and alarming painful miseries. Hence, the recommended standards and guidelines for threshold RF exposure of SAR should be adopted at the global level to make 5G technology a successful one.

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Conflicts of interest

There are no conflicts of interest.

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