Adverse Effects of 5th Generation Mobile Technology on Flora and Fauna: Review Study

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Abstract. Technology plays a very vital roles in the growth of the economy of any nation. Hence, information communication channel needs to be very strong for timely delivery of information and growth of any country. Mobile technology is the backbone of communication channel in any country who has incorporated it. Since 1980 mobile communication is very popular mode of communication and researches are going on in this area since that time. Starting from the first generation mobile network to fifth generation mobile network, every nation wants to enhance their information communication technology infrastructures in aspect of communication. The 5G mobile technology is subject of debate now a day. Still, most of the countries are in the race for adopting this technology and are ignoring its adverse effects on human health and environments. 5G mobile technology uses millimetre waves and higher frequency band 6 GHz to 100 GHz for communication. Initially, there was appeal made in United Nation Council and later in European Union against the launch of 5G, which was signed by more than three hundred scientists and doctors, stating that the 5G mobile technology is not good for environment. Various research has been conducted regarding the adverse effects of RF-EMF waves, which are generated by cell towers, on human health and environment. 5G uses very dense infrastructure and there is evidence that the RF-EMF radiation level is very strong in fifth generation mobile technology as compare to previous mobile technologies. Hence, the current study is focused on reviewing the impact of 5G mobile technology on flora and fauna Kingdom.

1. Introduction

Technology is very important for the human being in this revolutionary era; it is also helpful in the growth of the country’s economy. Information communication Technology (ICT) movement toward mobile generation technologies focuses on mobility, latency, data rate and providing connectivity to the end user. Currently almost every nation has adopted the LTE network related to fourth generation mobile technology. This LTE technology emphasises on high-speed mobile network that provides fast handover, low latency and high transmission data rate. The 5th generation mobile technology operates on 6 GHz to 100 GHz frequency, also called millimetre and sub-millimetre waves, and cannot travel to longer distances. When compared to earlier generations, for setting up a 5G network higher number of mobile base stations are required. A 5G base station has cell radius of maximum 20 meters, leading to the fact that about 800 base stations per square kilometre will be required to setup a 5G network. This implies that in a highly populated area two antennas will be required at every ten houses. The 5G network
The setup cost is high because base stations are placed closer. The 5G millimetre waves have longer wavelength and lower frequency, which makes them less powerful in term of energy. Initially organizations tested the millimetre frequency of 6 Ghz to 30 Ghz for initial installations. Later on they increased it up to 100 Ghz for achieving higher speed communications. But these waves can travel only to short distances, hence they led to denser 5G network infrastructure [1]. 5G uses higher frequencies that travel in shorter distances and require dense infrastructure setup, these type of waves are called millimetre waves; they can create very strong radio frequency electromagnetic field (RF-EMF). EMF filed is invisible form of Energy. Radiation are two types Ionising and Non-ionising as per figure 1, Ionizing radiations are very harmful for human body, it can damage human cells and can causes cancer. Non-ionising radiations are safe to use but many scientists have suggested that they can create only thermal effect or tissue heating at higher exposure level on human body, which may lead the long term effects of human health and environment.

![RF-EMF Spectrum](image)

**Figure 1.** RF-EMF Spectrum [2]

A group of scientists stated that there are adverse impacts from EMF exposure, which will increase with the implementation of 5G wireless network, because of its strong electromagnetic fields. An appeal was presented to the United Nations in 2015 and to the European Union in 2017, with an increasing number of scientists' signing (268 scientists and medical doctors as of 18 December 2019) [3]. While 50% of the scientist community found that there is no adverse effect on 5G radiation, the statement denied by many researchers because of lack of research in this field. Most of the researches were performed in laboratory on single carrier wave frequency, which would not generate a strong electromagnetic field (EMF is in the form of pulsing and modulation). But actual setup of 5G infrastructure superimposed various frequencies (lower frequency also present in telecommunication) that will create strong EMF. Secondly the entire laboratory tests were conducted in animals, mostly rats and mice, every species have different characteristics to absorb radiation. Here radiation penetration depth depends on function of frequency, tissue and other parameter, these are different from animal to human. EMF can penetrate animal more deep in skin with their different organ, tissue could be affected according to power density [4]. In 2020 most of the continent like USA and Europe implemented the fifth generation infrastructure in their country to empower their economy and boost their private, public and defence infrastructure. The rest of the paper is organised as follow, section 2 describes about the adverse effect of the 5th generation mobile technology on human health, section 3 describe about the adverse effects of the 5th
generation mobile technology on animals and plants, section 4 describe about comparative analysis of 3G, 4G, 5G technology adverse effect and possible solution and section 5 conclude the paper.

2. Adverse Effects of the 5th Generation Mobile Technology on Human Health
Telecommunication companies worldwide, with the support of the government, deployed 5th generation technology. It started from China then USA, Europe and other developed countries implemented it. China based Hawaii Company is the leading manufacturer for developing the 5G infrastructure worldwide, however other companies are also working in the deployment of the 5G infrastructure. 5G infrastructures play very big role in boosting the economy of the country preliminary from development that will be smart home, smart city, smart business, smart highway, driverless vehicle, massive IOT devices that are capable to store data in cloud. Every individual on earth can access high speed wireless connection with very low latency, always connected to public internet. Due to its wide range of available application in IOT, cloud based storage and high speed internet access, every country wants to adopt the 5G mobile technology to empower their economy. The main point ignored by entire nations is its adverse effect in the environment [5]. 5G infrastructure uses 6GHz to 100Ghz frequency (Sub-millimetre and Millimetre wave) to transfer data, Millimetre waves cannot travel longer distance and have poor penetration capability for solid. Due to that the carrier needs to install base station every 100 meter. The infrastructure of the 5G networks have massive antenna everywhere, near office, footpath, streetlight, at home, park and every street. 5G antennas are arranged in ‘Phrased Array’ that work together to emit focused, steerable, laser like beam which tracks each other [6].

2.1. Skin Effects
5G mobile technologies formed a strong EMF that causes tissue heating and burning in the skin or rashes in the skin. During initial phase of 5G, which was deployed in USA, people noticed that they got rashes on their skin. Though there was no study carried out that the rashes appeared on the skin due to 5G radiation exposures, but there are many studies reporting that there are adverse effects of 5G radiation on skin tissue and thermal effects notified on human body. Millimetre waves have skin penetration power up to 1.0 mm, when millimetre waves strike on the skin some of its waves reflect back and some are absorb by skin. The Specific absorption rate (SAR) can be measured by the rate at which energy of radio frequency absorbed by the human body, there is strict guideline issued by International Telecom Union to all service provider. The FCC limit for public exposure from cellular telephone is an SAR level of 1.6w/kg, the basic restriction on SAR value prevents excessive tissue heating and minimizes stress. Elementary restrictions for human whole-body exposure in expressions of SAR are 0.4 W/kg in occupational settings and 0.08 W/kg for general public exposure as describe for 5G network. However skin penetration and absorption of millimetre waves depends on various factors that are different according to gender, skin, body type, hydration level and skin thickness. A naked skin has more exposure as compared to covered skin and sweat also play major role in absorbing radiations [7]. Skin is made of two layers that are outer epidemics and underlying dermis. Dielectric properties of the human skin need to be considered where the source of radiation is close proximity to the body. Around 40% of the incident power is reflected at the skin surface and remaining 90 % of the power is absorb by epidermis and dermis layer of the skin. Due to this property human skin is able to absorb the electromagnetic radiation that causes various skin related diseases. However the penetration power of millimetre waves is not deep in the human skin because of that it can only create the thermal effect on the human body [8].

2.2. RF-EMF Exposure Effects
5G mobile technology uses non-ionising radiation (Millimetre waves) perceiving that it is harmless due to lack of potency, but here potency is not a tricky the main problem is their pulses due to dense network. 5G mobile technology uses a phased grid narrow beam antenna that directly points toward user, the main problem is that around in one km of radius about 800 antennas need to be setup that will create a strong concentrated electromagnetic filed. So the radiation emitted by 5G base station will be ten to
hundred times greater than 4th generation technology cell station. The cellular antenna mounted everywhere in 5th generation network, near park, street, home roof will create a huge electromagnetic field exposure as compared to previous generation network, because a person is near to transmitting antenna is at more exposure of electromagnetic field [9]. There are a lot of researches carried out related to dangerous health effect of EMF exposure to human body. Pulse EMF creates various harmful effects on human being related to irritation, excessive stress, DNA damage, loss of sperm count, loss of memory, even more serious circumstances the excessive exposure of EMF field create cancer as the study carried out by US National Institute of Health (NIH). A person who heavily uses cell phones can prone to brain tumour, even a person who puts cell phone in their shirt pocket are prone to cardiovascular disease. EMF fields are more dangerous for children, now a day children are using electronic gadget excessively, and the strong EMF filed directly damages their memory power, brain competency that lead to neurological disorders [10]. Excessive exposure (who are living close to signal transmitted antenna) of electromagnetic radiation can increase chance to get infected with cancer by 300 %.

2.3. Neurological/neuropsychiatric Effects
Navarro EA et al [11] stated that the person living near to electromagnetic fields is more prone to develop various health risks, like depression, headache, memory loss, irritation, sleep disturbance, loss of appetite, dizziness, loss of vision and cardiovascular disorder.

2.4. Gene Expression
Gene expression is process by which the information encoded in a gene is used to direct the assembly of a protein molecule. Some of the study suggested that EMF generated above the frequency for 30 GHz can change in gene expression.

2.5. Fertility
As per a study carried out by various researchers, there is high impact on sperm quality due to excessive exposure of EMF radiation [12]. It also affects female fertility rate by changing their ovarian remodelling and oocyte loss. Various studies suggest that total of 50 % fertility rate drop in human being was observed in those persons who were excessively exposure to EMF radiation for many years.

2.6. Hormonal Effects
5G radiation exposure can bring hormonal changes in human body, steroid hormone level can drop and other hormonal levels can increase. Due to change in hormonal condition in the human being various problem encountered like rashes on skin, thyroid, and growth of organ and appetite disturbance.

3. Adverse Effects of the 5th Generation Mobile Technology on Animals and Plants
5G technology has effects not only on human being, but it also affects the animals and plants species on the earth. Electromagnetic radiation exposure for a short duration of time does not has dangerous health effects, but if anybody has long term exposure to the radiation it may cause some serious hazards on human health. As compared to human being, animal and plant species are more affected by the radiation, as their genetic structures are different from human being. A number of studies have been carried out regarding radiation effects on various species.

3.1. Impact on Birds Species
An observational study carried out by Diana kordas [13] regarding bird’s population that deceased in north Greece due to cell tower radiation stats that there are lot of bird’s species missing in the northern Greece area due to radiation’s harmful effects. Electromagnetic radiation has long term effects on the birds such as crows, owls, sparrows, however crows and pigeons families are not affected as much as sparrows. Because of this many birds family migrated across the non-radiation locations which were not in coverage of cell towers. At some of the lake where still using 3G mobile technology, the population of the birds is more as compared to the region where 4G cell tower is available. As per this study this
can be deduced that radiation have long term effects on the bird’s population. It is also observed by some scientists that radio frequency waves destroy the magnetic field of the earth that the birds follow for navigating their paths and sort exposure of electromagnetic radiation disorient them to fly to different location. Birds have thin skull with their wings acting as dielectric receiver that they use for navigational purposes. Because of the adverse effect of radiation birds are not able to breed further, a good example is sparrow species in India. Their population is decreasing continuously and in some of the northern parts of India they are at verge of extinction [13]. On the impact of radiation on the sparrows, in urban cities, a study was conducted in Delhi Region of India. Delhi region is one of the most populated cities in India and has large number of cell towers in that region [14]. Electromagnetic radiation is one of the leading factors responsible for the continuously declining number of sparrows in the region, however other factors such as urbanization, no place for their nest building, water shortage and temperature are equally responsible. House sparrow were one of the most abundant bird species near to human surroundings. But in 20th century, due to electromagnetic radiations generated by cell tower, their count is continuously decreasing [15]. The above-mentioned study was conducted by major researchers regarding the harmful effects on birds caused by electromagnetic radiation generated by 3G and 4G cell tower. Further in 5G network the cell towers are even denser as discuss in introduction section, hence it would create even stronger electromagnetic radiation fields as compared to earlier generations of mobile network.

3.2. Impact on Honey Bees

Honey bee play very important role in pollinate flowers. They take protein rich pollen back to their hives to nourish the other bees, in this process they pollinates flowers, which increases crop production. According to Richard and et al [16], in a honey bee colony, health and production are directly linked to queen. So for their experimental purpose they put electromagnetic radiations on the queen bee for fourteen consecutive days and found out that their hatching ratios was seriously affecting by the radiation, but their mating ratio was still the same. Study was conducted in experimental purpose and there are lot of factors need to be reconsidered like amount of exposure, distance of bees from exposures, source of radiation, other environmental condition like temperature and humidity. Most of the places in UK, Netherland, USA scientist observed and found out that due to excessive exposure of cell tower radiation honey bee were dying. So it is a serious matter because honey bees are good friends of nature and they play vital role in increasing production for many tropical crops.

3.3. Adverse effects on Zebra Fish

RF-EMF exposures are not associated with chemical compound, their effects are biological in nature, due to that there is no chemical reaction on the skin. A recent study conducted by Das Gupta, et al [17] on zebra fish embryonic development. The result generated by them did not revealed any large scale effects on embryo survival, but a modest depression of sensorimotor function was recorded. The experimental capability was limited for testing purpose only and RF-EMF was applied on zebra fish embryo for testing purposes. There was no adverse effect detected on their development and mortality rate. Here microwaves generated by cell towers were also absorbed by water, so before reaching to fish skin their some amount was already absorbed by the water. So, by this principal, it can be suggested that the radiation impact on fish was very less because they were never directly exposure to the radiation.

3.4. Adverse Effect on Plants

Plants are outstanding model for study adverse effect of RF-EMF generated by cell tower, because plants are immovable and there is constant and continuous exposure for them. A large number of experiments conducted in the laboratory shows that biological and chemical change occurs in plant after short duration of time when exposed to radiations. Biological traits may change depending on the varying environmental conditions. Laboratory experiments have various aspects as compared to real environmental conditions. Such as temperature, humidity, sun exposure, and amount RF-EMF absorb by other materials. In the laboratory experiments all of the factors are not available because open
environment is different than the lab environment [18]. A research project carried out by Jamie A. Dyvig [19] on effects of electromagnetic radiations on the plant growth revealed that the plant growth declined due to EMF exposure. The continuous radiation exposure of 2.4 GHz has resulted in 16.5% lower height in the radish plants and 5.1% lower mean height in the case of wheatgrass [19]. Long term exposure of RF-EMF can lead to change in the colour of the plant leaf from green to yellow, which can damage their further growth. The radiation generated from 5G mobile cells uses millimetre waves with higher frequency band, so in the case of 5G a strong RF-EMF will be formed that will effect plant growth and will reduce lifespan of the plants. A study based in America found out that the millimetre waves invoke peroxidase, a kind of stress protein in plants. This stress protein is responsible for damaging plant leaves; changing the colour of plant leaves from green to yellow and plants damage at last [1].

4. Comparative Analysis of Adverse Effects of 3G, 4G, and 5G Technology and Possible Solutions

3G technology brought the revolutionary era in the development of wireless networking. Multimedia technology to high rate data transmission, various technologies were adopted during this era. There were large number of base stations deployed during this era, for providing better end user connectivity and multimedia services. There is strict ICNIRP guideline for service providers, depending upon the population density in the region. Guidelines differ according to population density of the area and also impose number of safety standards and regulations for the users. These safety standards were necessary because scientists have already discovered the adverse effects of the wireless technology. The similar safety standards and safety guidelines with improvements were also provided by the regulatory body for 4G and 5G network technologies. 5G wireless technology have adverse effects on flora and fauna as discussed in the section 2 and 3. There are short term and long term effects of EMF-RF exposure. The short term effects are aches and pains, headache, decrease in sperm motility, tingling or burning sensation, anxiety, stress and irritability and the long term effects are cancers, brain tumours, fragmented DNA, mutated cells, neurological disorder [20]. 5G radiation effects on children’s brains are more as compared to adults because children’s brains are in growing stage, whereas adult brain has already developed. Studies show that impact of electromagnetic radiations imposes behavioural disorders and decreases the growth rate of brain among children as shown in table 1.

| Table 1. Comparative Analysis of Adverse Effects of 3G, 4G and 5G Technologies |
|-----------------|--------|--------|--------|
| Comparative Analysis | 3G | 4G | 5G |
| Technology | WCDMA | LTE | Millimetre |
| Skin Tissue (Heating) | No | Yes | Yes |
| Body Temperature | Not rise | Rise | Not rise |
| Penetration Depth on Skin | More (>10mm) | Less (approx. 1mm) | Less (0.41 mm for 42.24 Ghz) |
| Absorption of Energy | Low | High | Extremely High |
| EMF-RF Exposure | Less | More | Extremely More |

Based on the above table data, it is deducible that there are more skin tissue heating cases under 5G network, as compared to 3G network. Due to aligned grid antennas of 5G base stations focusing in particular direction, brings the crowded under higher exposure of harmful radiations, resulting in more skin tissue heating and burning effect on the skin. However, this problem is not persistent in 3G network, whereas 4G network imposes only little tissue heating effect. Comparatively, 5G radiation exposure produces lesser body heating effects, as compared to 3G radiation. This is because of the lesser penetration power of the 5G radiations on the human body. 5G network uses millimetre waves for communication that can travel shorter distance only and have less penetration power. As shown in the table it can penetrate up to 0.41 mm deep in skin at 42 Ghz band frequency, whereas the 4G radiation
can penetrate up to depth of 1mm in the human skin. However as discussed in the previous sections penetration depth also varies according to skin types. Absorption of energy is extremely high for the 5G radiations. As the 5G network uses millimetre waves, which have less skin penetration capabilities, but are easily absorbed by the human skin when they get mixed with the sweat. The use of allied directional grid antennas, which focuses in particular direction, increases the amount of energy deposition in the main lobe pointing toward human body. 5G uses large amount of base stations and millimetre waves that can travel shorter distances only. Hence more number of BSs are used in crowd due to mass deployments. Therefore, the EMF-RF exposure are more in 5G as compared to previous generations of mobile technologies [21].

4.1 Possible Solution
5G uses wireless transmission medium for communication and there is no existing technology that can remove the adverse effects of wireless networks. Hence, it becomes utterly important that every individual must follow some protective measures and all service providers must follow strict guidelines and safety standards while deploying the network. In his study Dahal Kul [22] has discussed about the adverse effects of mobile radiations on human, plants, and animals. The same study also suggests some protective measures to avoid those adverse effects, few of them are mentioned below.

- Keep distance as much as possible from cell phones and wireless devices.
- Reduce calls and cell phone usage.
- Avoid cell phone when network is weak and cell phone battery is low.
- Wait to speak and listen before call gets connected.
- Use headphone and toggle method (keep cell phone far from ear).
- Use Low SAR cell phone.
- Minimize cell phone usage.
- Best way to protect your house from radiation is to create highly conductive enclosure around your home, window should be painted with colours that reduces radiation effects.
- Turn off the Wi-Fi router if it is not in use.
- Keep cell phone out of bedroom at sleeping time. If the smart meter is installed at home, then use smart meter guard protection from radiation.

Another solution is QOC (Quantum Optical Communication). QOC is an alternative way in revolutionary communication era. It uses photons, the quanta of the electromagnetic field as flying qubits, which transports qubits from a physical quantum emitter. The use of photons as flying qubits has weak interaction with environment. It is assumed that through quantum communication adverse effects of radiation will not be perceived by the environment. The United States of America has already adopted the quantum theory and researches are going on in this filed [23][24].

5. Conclusion
5G has brought revolution in the mobile technology of the 21st century. For high speed data transmissions over wireless medium, 5G provides peak data rate of 20Gbps and latency of less than one millisecond. There is huge IoT infrastructure inbuilt in 5G wireless technology and advanced machine learning techniques to support the millions of machines to machine communications among devices. 5G is using millimetre wave technology and dense base stations infrastructure for communication. Various scientist communities have suggested that there may be the adverse effects of millimetre waves on the environment, but there is no strong evidence that suggests the adverse effects of millimetre waves on human health, if the exposure is only for a short duration. But based on the above review study, it is deducible that the higher frequency millimetre waves have adverse effects on humans, animals and plants species, if the exposure is for long term. Most of the experimental studies were conducted on rats, mice or other animals, whose biological structure were different from human beings. Further, the environments considered in the laboratory for the experiments have several factors that were different from real environments, making those results questionable. Effects of RF-EMF long term exposures are more dangerous as compared to those that appear because of short term exposures, because in long term
cases the exact cause of the ailments is difficult to find out. There were very few researches which were based on the exact real environmental exposures of RF-EMF radiations. Hence a proper experimental setup must be considered to find out the exact impact of 5G radiations on human health, animals and plants lives.

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