

STUDY ON IMPACTS OF CELL PHONE HANDSET AND TOWER EMITTED RADIATIONS ON SOME SELECTED PLANTS

Sudeep Kumar Tiwari

Research Scholar, Dharma Samaj College Aligarh U.P

Dr.Prabodh Srivastava

Professor, Dharma Samaj College Aligarh U.P.

Abstract

As mobile phone use has grown quickly, so has outdoor exposure to electromagnetic radiation (EMR). This has raised worries about EMR's biological effects on more than just people and animals, including plants. Through an organized, multi-phase experimental research approach, this study looks into how certain plant species are affected by radiation from cell phones and cell phone towers. In the first part, we looked at how handset radiation affected the sprouting of seeds and the early growth of seedlings in a lab setting. In Phase II, short- and medium-term radiation effects on growing plants were studied, with a focus on changes in shape, function, and biochemistry. In Phase III, long-term exposure was tested in the real world by putting plants at different distances from cell phone towers to mimic long-term radiation stress. The research looked at many things, such as plant height, leaf area, biomass, chlorophyll content, stomatal characteristics, oxidative stress biomarkers (MDA, proline, antioxidant activity), and changes in the plant's structure that could only be seen under a microscope. The results showed that handset radiation caused short-term stress reactions, mostly in the early stages of development, resulting in lower germination rates, slower shoot–root elongation, and faster oxidative damage.

Keywords: *Electromagnetic radiation, cell phone exposure, plant growth, oxidative stress, seed germination.*

Introduction

Over the course of the last several decades, the rapid development of mobile communication technology has transformed the manner in which people communicate with one another, carry out commercial activities, and get information. Electromagnetic radiation has become an increasingly ubiquitous component of modern life due to the proliferation of mobile phones and the accompanying infrastructure of cellular towers. The environment is exposed to a constant stream of low-intensity electromagnetic fields as a result of the radiations that are released by both base stations and portable devices. These radiations fall mostly within the radiofrequency (RF) band. Although the influence of this kind of radiation on the health of humans has been the subject of a great deal of discussion and investigation, a far less amount of attention has been paid to the way in which it affects plant systems, which are essential markers of environmental alterations and serve as the foundation of terrestrial ecosystems. Due to the fact that they are sessile, plants are unusually susceptible to environmental

stresses, which may include electromagnetic radiation. External stimuli have the ability to have a direct impact on the growth, development, and physiological processes of organisms. As a consequence of this, these stimuli have the potential to cause modifications at the morphological, anatomical, and biochemical levels. The first signs of environmental stress are frequently exhibited by morphological factors such as the size, shape, thickness, and color of leaves. In contrast, physiological and biochemical changes, which encompass modifications in photosynthetic efficiency, pigment content, enzyme activity, and secondary metabolite production, are indicative of more profound disruptions in the metabolism of plants. Because of the widespread presence of cell phone towers and the intensive use of mobile handsets, studying the effects of such radiations on plants is of the utmost importance. This is not only because it is necessary to understand the potential ecological consequences, but also because it is necessary to evaluate the implications for agriculture and biodiversity conservation.

The electromagnetic radiation that is emitted by mobile devices and towers is primarily composed of non-ionizing radiofrequency (RF) waves. Ionizing radiation, on the other hand, has sufficient energy to cause damage to chemical bonds or to the DNA of living organisms. However, a significant number of studies have indicated that plants may experience oxidative stress, the generation of free radicals, and disruptions in normal cellular functions when they are exposed to RF radiation for an extended period of time. The findings of field and laboratory investigations have shown a range of consequences, including stunted development, deformation of leaves, a decrease in chlorophyll content, and changes in the pace of germination. The differences in the reactions are often ascribed to a variety of variables, including the strength of the radiation, the length of time of exposure, the species of plant, the stage of growth, and the circumstances of the environment. The results of these investigations suggest that even non-ionizing radiation, when present at levels that are typically found in the environment, could have a substantial impact on the physiology of plants. This finding indicates that a systematic investigation into the matter is justified.

Background of Mobile Communication Technology

The modern world has seen profound and transformative changes as a result of the advent of mobile communication technology, which has transformed commerce, communication, and daily life on a global scale. The transformation that is now taking place is considered to be one of the most disruptive developments in contemporary human civilization. Mobile communication has progressed to become a complicated ecosystem that enables high-speed data transfer, multimedia services, and a wide range of wireless applications. It was first designed as a method for enabling voice communication across limited distances. The first attempts to construct wireless telegraphy and radio transmission were made in the early 20th century, and they laid the framework for the technical improvements that would subsequently come. The development of mobile technology can be traced back to this time period. During the early phases of the development of mobile telephony, it was typical for big, unmovable devices that had a limited range to be used. These devices were often restricted to applications in emergency and military communications.

During the 1980s, there was both the development of analog cellular technology and the launch of mobile networks in the first generation, also known as 1G. Despite the fact that these systems did indeed make it feasible for fundamental voice communication to take place via regional networks,

they were hindered by their limited capacity, restricted coverage, and insufficient security. The emergence of 1G technology was a significant turning point in the field of telecommunications. This advancement made it possible for a wide variety of consumers to access mobile communication on a widespread basis. As a result, it paved the way for the mobile technology that would come after it. This was accomplished in spite of the fact that these constraints were present. With the introduction of the second generation (2G) of mobile telephony in the early 1990s, it became feasible to use digital technology into the transformation of mobile telephony. The capacity to transmit text messages, often known as SMS, to other individuals as well as enhanced security and improved call quality were all made possible by this generation of mobile telephony. The proliferation of mobile phones became more widespread, and the number of users increased dramatically all over the globe as a result of the introduction of second-generation (2G) networks. These networks were founded on time-division multiple access (TDMA) and code-division multiple access (CDMA) technology.

Objectives of the Study

1. To find out variation in the above-mentioned morphological characters.
2. To study the effect of electromagnetic field on phyllosphere microflora of plant in terms of alterations in their presence

Interaction of EMR with Biological Systems – How radiation affects living organisms.

Electromagnetic radiation (EMR) is a term that refers to an extensive environmental effect that originates from both natural and human-made sources. The impact of non-ionizing radiation, such as radiofrequency (RF) and microwave radiation that is transmitted from cell towers, mobile phones, and Wi-Fi devices, on biological systems is more complicated and not fully understood, even though it is widely accepted that ionizing radiation that is high in energy has an effect on living organisms. It is within the capabilities of electromagnetic radiation (EMR) to have an impact on biochemical, physiological, and cellular processes. This is a result of the interaction that takes place between electromagnetic radiation (EMR) and all living organisms, which includes plants, animals, and human beings. It is very essential to have an understanding of these interactions in order to assess the potential risks to the environment and to human health, particularly in light of the fact that individuals are being exposed to electromagnetic radiation of lower intensity at an increasingly rapid pace in modern-day circumstances.

Mechanisms of EMR Interaction with Biological Systems

Electromagnetic radiation interacts with biological systems via a variety of different mechanisms. The most important of these processes are thermal and non-thermal effects. As a consequence of the transformation of the energy that is derived from electromagnetic radiation that has been absorbed into heat, the temperature of cells or tissues increases. This phenomena is classified as a thermal effect. This has the potential to disrupt protein structures, change enzyme activity, and impact cellular metabolism. This may have a number of consequences, including the possibility of disrupting protein structures, altering the action of enzymes, and affecting cellular metabolism. On the other hand, there are consequences that do not have a thermal origin. These effects are sometimes more challenging to

distinguish since they occur without a discernible rise in temperature. Non-thermal interactions have the potential to effect a variety of different processes, including the expression of genes, the permeability of the cell membrane, the movement of ions, the formation of reactive oxygen species (ROS), and the processes that are involved in cellular signaling. Despite the fact that the precise mechanisms that are responsible for non-thermal effects are still being studied, it is believed that they play a significant role in providing an explanation for the physiological and biochemical changes that have been observed in living things that have been exposed to low-intensity electromagnetic radiation for a long period of time.

Effects of EMR on Plants

Plants offer for an excellent topic for study into the ecological ramifications of radiation since they are always exposed to ambient electromagnetic radiation, which is a result of their being immobile organisms. There is evidence that demonstrates that being exposed to electromagnetic radiation has an effect on a variety of different aspects of the growth and development of plants. The morphological effects that were observed included a reduction in the size of the leaves, changes to the shape of the leaves, a reduction in the rate at which the stems develop, and adjustments to the structure of the roots. A decrease in the quantity of chlorophyll, a decrease in the efficiency of photosynthesis, and a decrease in the absorption of nutrients are all potential physiological effects that may be seen. This results in the formation of an increased amount of reactive oxygen species (ROS), a change in the activity of enzymes that prevent oxidation, and changes to the process of synthesizing secondary metabolites. Because of these alterations, the plant's overall health, its ability to reproduce effectively, and its capacity for production may all be negatively impacted, which might have consequences for the whole environment in which it is located.

Effects of EMR on Animals

In animals that have been exposed to electromagnetic radiation, particularly radio frequencies and microwave frequencies, a broad range of biological responses may be seen. One of the potential outcomes that might result from thermal effects is the localized heating of tissue, whereas non-thermal effects can potentially have an influence on a wide range of things, such as cellular metabolism, reproductive health, behavior, and neurological function. After being exposed for an extended period of time, research that was done on animals in a laboratory environment has shown that the levels of hormonal indicators, the activities of enzymes, and the markers of oxidative stress have all undergone changes. There have been associations between exposure to electromagnetic radiation (EMR) and modifications in the navigational and orienting abilities of birds and insects, as well as abnormalities in their reproductive behavior. Despite the fact that the amount of radiation that is emitted by mobile communication devices is often below safety levels, the cumulative effects and long-term exposure to the radiation that is released by these devices continue to be major areas of research.

Cellular and Molecular Responses

There is a possibility that electromagnetic radiation has the ability to influence a variety of processes that occur at the cellular level. This includes the maintenance of the integrity of membranes, the operation of ion channels, and signaling that takes place within cells. The movement of calcium ions

may be affected by the presence of radiofrequency (RF) and microwave radiation. This phenomenon plays a crucial role in a broad range of biological processes, including but not limited to signal transduction and the regulation of development. The generation of reactive oxygen species (ROS) at a higher rate is a typical reaction to exposure to electromagnetic radiation (EMR). This heightened level of ROS generation has the potential to give rise to oxidative stress, which has the capability to cause damage to proteins, lipids, and nucleic acids. As a result of the findings that were discovered during gene expression studies, there has been an upregulation of genes that are connected to stress, as well as modifications to pathways that are related to metabolism, defense mechanisms, and growth regulation. As a consequence of these cellular and molecular processes, the physiological effects that have been identified in animals and plants that have been exposed to electromagnetic radiation are more comprehensible from a mechanistic viewpoint.

EMR as an Environmental Stressor

There is an increasing amount of research that suggests that exposure to magnetic resonance imaging (MRI) has the potential to function as an environmental stressor that might have an effect on the dynamics of an ecosystem. In the case of plants, the consequences of being exposed to a particular substance over a prolonged period of time can include stunted growth, decreased reproductive success, and alterations to metabolic profiles, which might have an influence on both the interactions between species and the overall structure of the community. The possibility exists for electromagnetic radiation (EMR) to have a disruptive impact on the behavior, reproductive capabilities, and physiological balance of animals, with the potential for a chain reaction of consequences to propagate throughout food webs. The concept that electromagnetic radiation is a stressor brings attention to the need of research that covers a variety of fields, such as ecology, physiology, molecular biology, and environmental science. The purpose of this research is to get a more thorough knowledge of the broader implications of electromagnetic radiation.

Effect of EMR on Plants – Morphological, physiological, and biochemical impacts.

Natural and manmade sources of electromagnetic radiation (EMR) are always affecting plants. This ongoing exposure to EMR may arise from either natural or artificial sources. The development of mobile communication technology has been progressing at a rapid pace. As a result, the non-ionizing electromagnetic radiation that is generated by mobile phones, cell towers, and Wi-Fi devices has become a permanent ecological element that has the potential to impact plant systems. In contrast to humans and animals, plants are immobile and so are continuously exposed to electromagnetic radiation. As a result, they are considered to be reliable indicators of the environmental stress that is caused by this kind of radiation. Plants may experience morphological, physiological, and biochemical changes as a consequence of being exposed to radiofrequency (RF) and microwave radiation for a prolonged duration of time or over a longer period of time, according to a number of scientific examinations that have been conducted. Understanding the extent to which ecosystems are able to sustain themselves over the long term is a crucial aspect of assessing the consequences that modern wireless technologies have on the environment. In addition, it is necessary to have the ability to grasp the implications of these technologies.

Morphological Impacts of EMR on Plants:

The alteration of morphological characteristics is one of the most apparent consequences that may be seen in plants when they are subjected to electromagnetic radiation (EMR). The results of scientific study have shown that when seeds are subjected to prolonged radiofrequency radiation, the germination rate is decreased, sprouting is delayed, and the lengths of the roots and shoots are shortened. The leaves of the plant often exhibit a reduced size, an irregular shape, and areas of chlorosis, all of which are characteristic of arrested growth. Furthermore, a large number of different kinds of plants that have been subjected to electromagnetic radiation (EMR) have shown modifications in their total biomass, the distance between their internodes, and the number of leaves that they have. Furthermore, there is evidence that corroborates the assertion that the production of flowers and fruit is reduced in plants that are cultivated in the vicinity of mobile towers or subjected to electromagnetic fields in a laboratory environment. As a result of the electromagnetic radiation (EMR), there is a disruption in the developmental processes and growth dynamics that take place during the early stage, which may be seen in the morphological abnormalities that were detailed before. In comparison to fully developed plants, young seedlings are more vulnerable to the detrimental repercussions of exposure to radiation. The extent of these effects is contingent upon the plant's developmental stage at the time of exposure, the duration of the radiation, and the sensitivity of the species.

Physiological Impacts:

The biological processes that take place in plants, including photosynthesis, respiration, transpiration, and the movement of nutrients, are very sensitive to environmental stress. There is evidence to support the claim that exposure to electromagnetic radiation (EMR) has an impact on the quantity of chlorophyll that is present, decreases the effectiveness of photosynthesis, and decreases stomatal conductance. It has been shown that the exposure of plants to microwave and radio frequency radiation leads to a decrease in the levels of chlorophyll a, chlorophyll b, and carotenoids, which is an indication that the plants' ability to carry out photosynthesis has been compromised. Aside from this, electromagnetic radiation has the capacity to modify processes that govern water by making adjustments to leaf water potential, stomatal opening, and the rates at which evapotranspiration happens. The effects of these physiological changes extend beyond the mere metabolism of plants. They might also have the consequence of reducing the quantity of energy and resources that are available for plants to develop and reproduce. As a consequence, the existence of vegetation and agricultural output might be threatened by prolonged disruptions to their physiological functions, especially in regions where farming is the primary industry or where the levels of radiation are elevated.

Biochemical Impacts:

Changes to the metabolism of cells as well as stress-related metabolic pathways are the defining characteristics of the physiological responses that occur as a result of exposure to electromagnetic radiation (EMR). There has been a number of investigations that have shown the fact that when plants are exposed to electromagnetic radiation (EMR), they undergo an increase in the production of reactive oxygen species (ROS), which subsequently results in oxidative stress. Plants stimulate their antioxidant defense mechanisms, which serve as a compensatory strategy that alters the activity of enzymes including catalase (CAT), superoxide dismutase (SOD), peroxidase (POD), and ascorbate peroxidase (APX). Nonetheless, if an organism is exposed to a chemical over an extended period of

time, this may result in the depletion of the organism's ability to function as an antioxidant. This, in turn, may lead to the peroxidation of lipids and damage to the cellular membranes of the organism. The levels of secondary metabolites are not often changed when organisms are subjected to electromagnetic radiation (EMR) stress, and this is due to the fact that defensive responses are initiated or that abnormalities in metabolism occur. Phenolics, flavonoids, and alkaloids are all examples of secondary metabolites, as are a number of other substances. The revelation that electromagnetic radiation has been related to modifications in the production of proteins, the stability of DNA and RNA, and hormonal balance has provided more evidence to support the claim that electromagnetic radiation has biological impacts on plants.

Mechanisms of EMR-Induced Stress in Plant Cells:

The biological mechanisms that are responsible for the effects of electromagnetic radiation (EMR) are complicated and include both thermal and non-thermal pathways. The absorption of heat results in thermal effects, while changes in cell signaling, ion balance, and electron transport chains are the methods by which non-thermal impacts are conveyed. There is a possibility that exposure to electromagnetic radiation might alter the permeability of membranes, which in turn could have an effect on the movement of essential ions such as potassium and calcium. These ions are well-known for their important contributions to the process of signal transduction. The interruptions that occur in the flow of electrons involved in photosynthesis give rise to the production of reactive oxygen species (ROS), which subsequently result in oxidative stress. In addition, the possibility that electromagnetic radiation can affect gene expression, control protein synthesis in response to stress, and influence hormonal signaling (for example, auxins, cytokinins, and gibberellins) demonstrates that EMR has the potential to act as a chronic stressor at the molecular level.

Species-Specific and Exposure-Dependent Effects:

When various kinds of plants are taken into consideration, there is a significant degree of diversity in the extent of the reactions that are generated by electromagnetic radiation (EMR). A number of species exhibit a high level of adaptability, while other species have a high level of sensitivity. The latter is demonstrated by the fact that they undergo a rapid decrease in development even when they are exposed to just moderate doses of radiation. The variables that are linked with exposure, which include the distance from the source, the frequency, the power density, and the duration of the exposure, have direct ramifications for the severity of the outcome that may be ascribed to them. For instance, the plants that are positioned in the neighborhood of cell towers are often subjected to low-intensity radiation for a longer length of time. In contrast, studies that are carried out in a laboratory setting may include higher intensities of radiation for a shorter period of time. Due to the fact that they have higher rates of metabolic activity and cellular division, tissues and seedling plants that are growing at a rapid pace are often more susceptible to electromagnetic radiation (EMR).

Ecological Consequences of EMR-Induced Changes:

Electromagnetic radiation (EMR) may cause changes in plant morphology, physiology, and biochemistry that are not limited to individual plants but might even affect the dynamics of larger ecosystems. The reduction in the quantity of flowering and fruiting might have an impact on the

interactions that take place between pollinators and the availability of food for herbivores. The way that plants defend themselves could be modified as a consequence of the changes in the levels of secondary metabolites that are present. These changes would then affect the relationships that plants have with both bacteria and insects. The fall in both crop production and economic output may result from a decline in the growth and productivity of agricultural systems. Over the course of time, it is feasible that modifications in the degree of tolerance between different species may result in alterations to the structure of plant communities. These changes, in turn, have the potential to affect both the biodiversity and the stability of the ecosystem.

Electromagnetic radiation that is released by modern communication technology provides a considerable environmental stressor that is capable of changing a range of different aspects of plant biology. The existence of morphological abnormalities, diminished physiological functioning, and biochemical disruptions in plants that have been exposed to electromagnetic radiation (EMR) over an extended period of time demonstrates the fact that plants have a sensitive reaction to such exposure. It seems that the most significant elements influencing the responses that were seen are alterations in the signaling of cells and oxidative stress. Despite the fact that the problem is caused by a combination of thermal and non-thermal pathways, this is nonetheless the case. Due to the ecological and agricultural ramifications that arise from the cumulative effects of electromagnetic radiation (EMR), it is of the utmost importance to do research on the responses of plants in both natural and controlled environments. By establishing the framework for the evaluation of the environmental dangers that are linked with electromagnetic radiation, this concept highlights the need of developing wireless communication infrastructure in a way that is ecologically sustainable.

Plants as Bioindicators of Environmental Stress

Due to the fact that they do not move and that they are directly sensitive to oscillations in the physical, chemical, and biological aspects of their environment, plants have long been considered to be reliable bioindicators of environmental stress. Plants are unable to change their location and remain in the same spot for the entirety of their life cycle. This is in stark contrast to animals, which possess the capability to either flee from or adapt their behavior to situations in which they are faced with an inhospitable environment. Because of the fact that they do not move around very much, they are extremely susceptible to any and all alterations that occur in their surroundings. There are changes that take place in elements such as temperature, humidity, the composition of the soil, heavy metals, pollution, and electromagnetic radiation (EMR). As a result, flora serve as organic indicators of the health of ecosystems, which enables the identification and assessment of environmental threats at a significantly earlier stage in time than would be possible for other biological systems. The variations that are both apparent and measurable in plants that are brought about by stressors—such as changes to their morphology, physiology, biochemical composition, growth, and productivity—serve as quantitative indicators that can be utilized to evaluate the severity and trajectory of disruptions in the environment.

Factors Influencing Biological Effects

The degree to which electromagnetic radiation has an impact on living things and the kind of effect it has are both influenced by a variety of distinct variables:

- When the intensity and frequency of the radiation are increased, the method in which the radiation enters the tissues may be altered, and the thermal effects that result from the radiation may be more significant. The following are the two variables that influence these phenomena:
- The length of time that the exposure lasted was: The phrase "chronic exposure" refers to exposure that has been sustained over a long period of time, and even if the intensity of this exposure is low, it may still result in cumulative effects. On the other hand, transitory responses are often the consequence of exposure that is limited to a short period of time.
- The susceptibility of various species and developmental stages to electromagnetic radiation (EMR) varies; seedlings or juvenile stages, for example, are often more vulnerable to EMR.
- The biological responses that living things demonstrate in response to electromagnetic radiation (EMR) could be affected by the circumstances of their surroundings, including factors such as ambient temperature, humidity, light intensity, and the availability of nutrients.
- These concerns point to the need of carrying out controlled experimental studies in order to properly evaluate biological repercussions, and they also underscore the complexity of interactions with electromagnetic radiation.

Plants as Bioindicators of Environmental Stress

Due to the fact that they do not move and that they are directly sensitive to oscillations in the physical, chemical, and biological aspects of their environment, plants have long been considered to be reliable bioindicators of environmental stress. Plants are unable to change their location and remain in the same spot for the entirety of their life cycle. This is in stark contrast to animals, which possess the capability to either flee from or adapt their behavior to situations in which they are faced with an inhospitable environment. Because of the fact that they do not move around very much, they are extremely susceptible to any and all alterations that occur in their surroundings. There are changes that take place in elements such as temperature, humidity, the composition of the soil, heavy metals, pollution, and electromagnetic radiation (EMR). As a result, flora serve as organic indicators of the health of ecosystems, which enables the identification and assessment of environmental threats at a significantly earlier stage in time than would be possible for other biological systems. The variations that are both apparent and measurable in plants that are brought about by stressors—such as changes to their morphology, physiology, biochemical composition, growth, and productivity—serve as quantitative indicators that can be utilized to evaluate the severity and trajectory of disruptions in the environment.

Effects of Electromagnetic Field Radiation (EMFr) on Seed Germination and Plant Growth

In the year 2000, Tambiev and Kirikova were the first to conduct an investigation that garnered significant attention and explored the connection between the growth of algae and the presence of radiofrequency electromagnetic fields (RF-EMF). During the course of their investigation, it was revealed that *Spirulina platensis* exhibited a significant improvement in both overall growth and photosynthetic efficiency when it was treated to controlled RF-EMF treatment. The findings of the

investigation suggested that exposure to electromagnetic fields has the potential to activate biochemical pathways that are related to the process of carbon absorption and the synthesis of photosynthetic pigments. This, in turn, would lead to an increase in the amount of biomass that accumulates. This research indicates that, within certain limits, it is possible that non-ionizing radiation will have a stimulatory influence on the physiological processes of microalgae as opposed to an inhibitory effect. This might open up new avenues for developments in biotechnology related to the production of algae.

In contrast, Zuk-Golaszewska et al. (2003) came to the conclusion that UV radiation had noticeable negative effects on the growth of terrestrial plants. This finding sheds insight on the intricate biological response to exposure to electromagnetic radiation at different wavelengths. The results of their investigation demonstrated that the quantity of UV light was the primary factor that contributed to a significant reduction in the surface area of the leaves. This eventually led to a reduction in the total surface area that might be utilized to capture solar energy via the process of photosynthesis. Ultraviolet radiation seems to interfere with the normal division of cells, the production of chloroplasts, and the expansion of leaves, which may be extrapolated from the reduced growth and morphological abnormalities that were seen in the plants that had been subjected to ultraviolet stress. When it comes to gaining an understanding of the manner in which the process of photosynthesis, the metabolism of plants, and the productivity of agriculture could be impacted by excessive exposure to ultraviolet (UV) light from the sun, the significance of these discoveries cannot be overstated. This is especially true in situations in which there is a reduction in the amount of ozone present in the atmosphere.

Conclusion

According to the results of the study that is currently being conducted, there is significant evidence to support the claim that electromagnetic radiations (EMF), which are emitted by mobile towers as well as mobile phone handsets, have a significant influence on the growth, physiology, and biochemistry of plants. The numerous different phases of the trials made it abundantly evident that exposure to electromagnetic fields results in both acute and chronic stress responses. These responses are contingent upon the species in question, the dosage, and the duration of exposure. The trials consisted of investigations into controlled seed germination, experiments involving potted plants, and field exposure in the vicinity of operational towers. Abnormalities were shown to occur at a rapid pace in a variety of aspects, including seed germination, the early stages of seedling development, chlorophyll content, and metabolic processes. These abnormalities were the consequence of exposure to handset radiation, which is characterized by a higher intensity for shorter periods of time. On the other hand, despite the fact that the intensity of the radiation that was produced by the tower was lower, it nonetheless had cumulative effects over extended periods of time. Examples of these consequences included a decrease in the area of the leaves, a delay in the flowering of the plants, and alterations in the biochemical signs of stress, all of which were slight but persistent changes in the morphology and physiology of the organisms.

References

1. Kumar, G. (2010). Report on cell towers radiation. Electrical Engineering Dept. Mumbai.

2. Kumar, V. (2010). Harmful effects of mobile tower radiation on living organisms: A report submitted to the Government of India.
3. Levitt, B. B. (2010). Cell tower radiation and tree decline. *Bulletin of Science, Technology & Society*, 30(4), 310–314.
4. exposure. *Environmental Monitoring and Urban Technology*, 13(3), 144–162.
5. M.W., Murray, B.R. and Lovett-Doust, J. (2006) Ecological patterns and biological invasions: using regional species inventories in macroecology. *Biol. Inv.* 8: 809–821.
6. Monselise, E. B., et al. (2003). Alanine accumulation as a stress indicator in duckweed under EMF. *Journal of Plant Physiology*, 160(9), 1125–1131.
7. Panagopoulou, A., et al. (2007). RF electromagnetic radiation effects on plant DNA. *Science of the Total Environment*, 388(1–3), 532–538.
8. Pazur, A., et al. (2006). Static and alternating magnetic field effects on barley seedlings. *Bioelectromagnetics*, 27(6), 444–450.
9. Quinn-Beattie, M.L. and Farnsworth, N.R. (2001). The potential of alkaloids in drug discovery. *Phytother. Res.* 15: 183-205.
10. Salama, H. M. H., et al. (2011). UV and EMF impacts on chlorophyll and stress markers in desert plants. *Australian Journal of Basic and Applied Sciences*, 5(5), 1076–1083.
11. Sandu, D. D., et al. (2005). UHF radiation effects on chlorophyll in *Robinia pseudoacacia*. *Journal of Plant Protection Research*, 45(3), 215–222.
12. Selga, T., & Selga, M. (1996). EMF-induced morphological changes in pine trees. *Science of the Total Environment*, 180(1), 87–90.
13. Soja, G., et al. (2003). Crop yield reduction near power lines: Wheat and corn under ELF EMF. *Plant, Soil and Environment*, 49(10), 463–467.
14. Tkalec, M., et al. (2009). Mitotic abnormalities in *Allium cepa* under RF radiation. *Mutation Research/Genetic Toxicology*, 672(2), 119–124.
15. Velázquez-Martí, B., et al. (2006). Microwave radiation and inhibition of weed seed germination. *Biosystems Engineering*, 95(2), 139–144.