Effects of Non-Ionizing Radiation of Cell Tower (CT) and High Voltage Transmission Line (HVTL) on Plants, Animals and Humans

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A thesis submitted to the Department of Mathematics and Natural Sciences in partial fulfillment of the requirements for the degree of Bachelor of Science in Biotechnology

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing a degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Abstract

This study investigates the potential health risks associated with non-ionizing radiation emitted by cell towers and high-voltage transmission lines through a comprehensive, survey-based research approach. Data was meticulously collected from various sites across Bangladesh that house these towers. This research aims to measure and analyze three critical electromagnetic field (EMF) components—Magnetic Field, Electric Field, and Radiofrequency (RF) strength—emitted by several towers, and compare them with established international safety standards for exposure. Non-ionizing radiation, often referred to as a "silent killer," poses long-term health risks, yet the population of Bangladesh remains largely unaware of its hazards. A total of 116 EMF data points were collected from seven divisions of Bangladesh, including Dhaka, Mymensingh, Chittagong, Barisal, Rajshahi, Sylhet, and Khulna. Of these, 76 were from cell towers and 40 from high-voltage transmission line (HVTL) towers, using a structured questionnaire designed to capture key metrics. Of Bangladesh were gathered using a structured questionnaire designed to capture key metrics. The data spans across multiple regions of Bangladesh and was subjected to both statistical and graphical analysis in order to evaluate the severity of the exposure. Our findings reveal a troubling trend: the majority of the 116 towers surveyed exhibit EMF levels significantly higher than the recommended exposure limits. This discrepancy is particularly alarming given the increasing number of towers in densely populated areas. By correlating the data with international safety standards, we demonstrate the heightened risk to public health posed by prolonged exposure to these elevated EMF levels. Finally, this research underscores the urgent need for increased awareness about the dangers of non-ionizing radiation in Bangladesh. The results not only highlight the gravity of the situation but also provide a foundation for future policy interventions aimed at mitigating exposure risks.

Keywords: HVTL, CT, EMF, Electric Field, Magnetic Field, Radio Frequency.

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Chapter 01

Introduction

In light of technological advancements, it has become commonplace for individuals in society to possess a cell phone, serving as a means of communication, work, and even entertainment. The prevalence of cellphones is unsurprising, given their increasing convenience in recent years. Nonetheless, the widespread usage of cellphones has led to a corresponding rise in the number of established cell towers and electric towers, both of which have become subjects of contention among various organizations concerned with environmental safety, such as the United States Environmental Protection Agency (U.S. EPA). Situated atop these towers, one can find communication equipment and antennas that transmit and receive signals from cell phones through the utilization of radiofrequency (RF) waves, including radio waves and microwaves.

Another significant source of electromagnetic radiation is electric towers, wherein power lines transport energy to residential and commercial buildings. The consistent flow of electricity results in the generation of low-frequency non-ionizing radiation. Heightened concerns regarding the link between power lines and cancer arose following a 1979 study that established a correlation between the two (Cancer.net, 2022). According to the American Cancer Society, radio waves and microwaves belong to the lower end of the electromagnetic spectrum, possessing comparatively lower energy levels in comparison to other types of electromagnetic waves (Johncox, 2023). Nevertheless, even minimal amounts of electromagnetic waves, when concentrated at high levels, can potentially be harmful if left uncontrolled for extended periods.

Electromagnetic radiation is categorized into two distinct types based on its severity: ionizing and non-ionizing radiation. Ionizing radiation possesses a substantial amount of energy and higher frequencies compared to non-ionizing radiation. It has the capability to dislodge electrons from objects it encounters, resulting in the ionization of matter. Examples of ionizing radiation include solar heat or light, X-rays emitted from X-ray tubes, and gamma rays emanating from radioactive elements. Conversely, non-ionizing radiation, including microwaves, RF radiation, infrared radiation, and ultraviolet radiation, carries a relatively lower amount of energy and exhibits lower frequencies when compared to ionizing radiation. Consequently, non-ionizing radiation does not possess the ability to ionize matter (Libre texts, 2023). It is important to highlight that most of the radiation produced by cell towers and power lines is classified as non-ionizing. However, this does not imply that they are entirely harmless, as concentrated levels of non-ionizing radiation, such as microwaves, can generate heat within bodily tissues and potentially lead to skin burns or cataracts.

Electric and magnetic fields (EMFs) have historically had adverse impacts on both domestic and wild animals, although these effects have become more pronounced in modern times due to the exponential increase in artificial sources of EMFs. It is worth noting that sources of EMFs have existed since long before the advent of human civilization, with the Earth and the Sun being two natural sources of EMFs. Naturally occurring EMFs are generally less harmful when compared to EMFs originating from artificial sources. Notably, domestic animals, such as cows, have exhibited particularly noticeable symptoms. A 1998 report published by the veterinary faculty of the University of Hanover documented a farmer's observations regarding peculiar symptoms in his cows subsequent to the installation of a nearby network tower. These symptoms included chronic conjunctivitis, characterized by persistently wet cheeks and excessive tearing eyes. Many cows engaged in head-banging against other cows, and some even averted their heads away from the direction of the transmitting tower. Mother cows were reported to be notably weak, and instances of birth failures were also documented. Although data on the effects of EMFs on domestic animals are relatively limited, certain studies have examined the effects on marine animals. Marine animals often rely on magnetoreception, the ability to sense and locate their prey. Transmission from cell and electric towers may disrupt this reception, consequently depriving them of their food source (Blank, 2023).

EMFs have also been found to impact plant growth and development, causing significant physiological and morphological alterations. Studies have highlighted various effects, including increased micronuclei formation, thinner cell walls, and smaller mitochondria. A field study, titled "Radiofrequency Radiation Injures Trees Around Mobile Phone Base Stations," published in the Science of the Total Environment, conducted a nine-year survey on over 100 trees. The study reported stunted growth in the majority of the trees under examination. However, the authors noted that a conclusive determination could not be reached, as the deployment of mobile phone base stations had continued without due consideration of environmental impacts. Another study, conducted on Aspen trees near Lyons, Colorado, and titled "Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings," was published in the International Journal of

Forestry. This study revealed adverse effects on plant growth, including a significantly reduced growth rate and a decline in anthocyanin production (Environmental Health Trust, 2023).

Hypothesis:

This study investigates the potential health risks associated with non-ionizing radiation emitted by cell towers and high-voltage transmission lines through a comprehensive, survey-based research approach. Data was meticulously collected from various sites across Bangladesh that house these towers. This research aims to measure and analyze three critical electromagnetic field (EMF) components—Magnetic Field, Electric Field, and Radiofrequency (RF) strength—emitted by several towers, and compare them with established international safety standards for exposure. Non-ionizing radiation, often referred to as a "silent killer," poses long-term health risks, yet the population of Bangladesh remains largely unaware of its hazards. This study seeks to shed light on this issue by providing empirical evidence of the exposure levels associated with these towers. A total of 116 EMF data points, among which 76 were cell towers and 40 were HVTL towers from across 6 out of 7 Divisions of Bangladesh were gathered using a structured questionnaire designed to capture key metrics. The data spans across multiple regions of Bangladesh and was subjected to both statistical and graphical analysis in order to evaluate the severity of the exposure. Our findings reveal a troubling trend: the majority of the 116 towers surveyed exhibit EMF levels significantly higher than the recommended exposure limits. This discrepancy is particularly alarming given the increasing number of towers in densely populated areas. By correlating the data with international safety standards, we demonstrate the heightened risk to public health posed by prolonged exposure to these elevated EMF levels. Finally, this research underscores the urgent need for increased awareness about the dangers of non-ionizing radiation in Bangladesh. The results not only highlight the gravity of the situation but also provide a foundation for future policy interventions aimed at mitigating exposure risks.

Chapter 02

Literature Review

In the realm of scientific research, the accuracy and reliability of experimental results are paramount. This principle holds particularly true for studies involving non-ionizing radiation, a field that encompasses various forms of radiation such as radio waves, microwaves, and infrared light. These forms of radiation, while less energetic than ionizing radiation, have profound implications in diverse areas ranging from telecommunications to medical diagnostics.

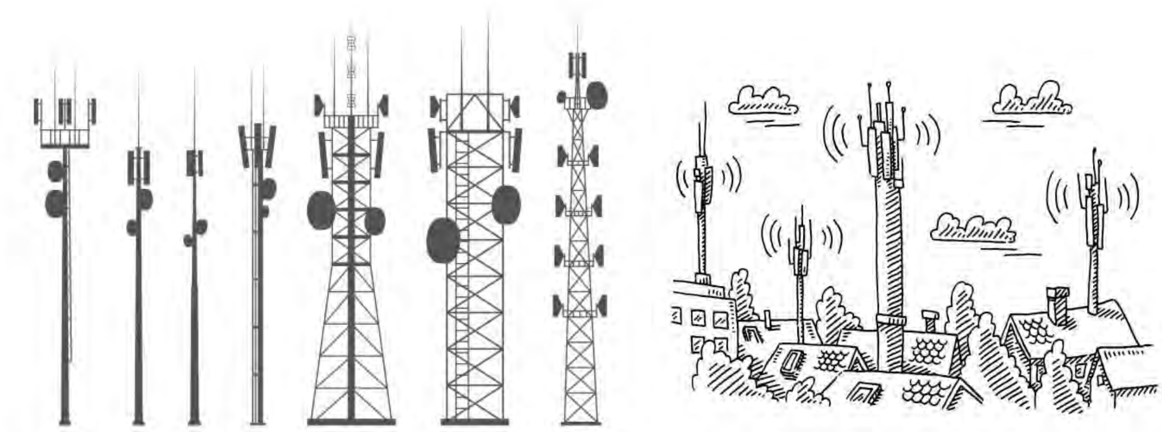


Figure 1: Cell Tower and High Voltage Transmission Line

However, a recurrent issue in past research on non-ionizing radiation has been the lack of proper calibration of measurement instruments. This essay explores how such calibration deficiencies have compromised research outcomes and the broader implications for the field. The past research papers that have concentrated on investigating the effects of non-ionizing radiation on living beings have largely ignored one particular aspect- using an universal calibration method. While using a universal calibration system is notoriously difficult, given how measurements are done in different units across the globe, the problem of having an inconsistent calibration system can be mitigated by having research equipment calibrated by the same organization. In Bangladesh, there are two major organizations that offer calibration services- Bangladesh Standards and Testing Institution (BSTI), and Bangladesh Reference Institute for Chemical Measurements (BRiCM). In this research, all of the utilized equipment were standardized through the use of BRiCM calibration services.

Calibration involves adjusting and validating the precision of measurement instruments to ensure they provide accurate and consistent results. For research involving non-ionizing radiation, this process is crucial because the intensity and frequency of the radiation must be accurately measured to understand its effects. Calibration errors can stem from various sources, including faulty equipment, improper calibration procedures, and changes in environmental conditions. When these errors are not addressed, they lead to inaccurate data, which in turn undermines the validity of research conclusions.

Another aspect lacking from past methodologies was the lack of updated standard values. Past research pursuits on the topic have often utilized data values that have become outdated. To rectify this, this endeavor used the most up-to-date and internationally recognized standard values available to the public, that additionally also align with the values used by BRiCM. Even though BRiCM does not share its standard values publicly, a general set of values can be deduced from their guidelines- electric field for the cell Tower is 0.5 V/m to 5 V/m, while the value for high voltage transmission line is 1 kV/m to 10 kV/m. Moreover, the value for magnetic field for cell towers is below 0.1 milligauss (mG). And for high voltage transmission lines are 1 milligauss (mG) to 200 milligauss (mG). The Optimum Range of Exposure of RF Strength for Cell Tower is below 45 µW/m^2, and the High Voltage Transmission Line is around 0.0000265 µW/m^2.

One notable example of calibration issues impacting research on non-ionizing radiation can be observed in studies related to microwave radiation. In the 1990s, many studies aimed to evaluate the possible health effects of microwave exposure., driven by growing concerns about the proliferation of microwave technologies. However, many of these studies suffered from inadequate calibration of the microwave measurement equipment. As a result, the reported exposure levels were often inaccurate, leading to flawed conclusions about the health risks associated with microwave radiation. Some studies either underestimated or overestimated exposure levels, causing confusion and controversy in the scientific community and complicating regulatory responses.

Similarly, research on radiofrequency (RF) radiation, which is used in wireless communications, has faced calibration challenges. Inaccurate measurements of RF exposure levels have led to inconsistent findings regarding the potential biological effects of RF radiation. For instance, studies examining the correlation between RF exposure and cancer risk have produced varying results, partly due to discrepancies in exposure assessment caused by calibration issues. This inconsistency has hindered the ability to draw definitive conclusions and has influenced public perception and regulatory policies regarding RF exposure.

The implications of calibration-related inaccuracies extend beyond individual studies. They can create a ripple effect that influences subsequent research and policy decisions. For example, if early studies with calibration errors report a lower risk associated with non-ionizing radiation exposure, this could lead to relaxed safety standards and guidelines. Conversely, if studies report exaggerated risks due to calibration inaccuracies, it could prompt unnecessary fear and lead to overly stringent regulations. Both scenarios highlight the critical need for accurate calibration to ensure that research findings are reliable and actionable.

To address these issues, it is essential for researchers to adhere to stringent calibration protocols and regularly verify the accuracy of their measurement instruments. This includes using well-maintained equipment, following established calibration procedures, and accounting for potential environmental factors that could affect measurements. Additionally, transparency in reporting calibration methods and potential sources of error in research papers is crucial. This allows other scientists to critically evaluate the validity of the results and replicate studies with a clearer understanding of the measurement conditions.

Chapter 03

Radiation Types

Radiation is a type of energy that moves through space and can interact with matter in different ways. It is a fundamental phenomenon that occurs naturally and can also be artificially generated for numerous applications. The term "radiation" often conjures images of nuclear reactors or medical X-rays, but in reality, it encompasses a wide spectrum of energy forms, ranging from the benign warmth of sunlight to the potentially hazardous emissions from radioactive materials. Understanding the different types of radiation is essential for comprehending their effects on plants, animals, and humans, especially in the context of non-ionizing radiation from cell towers and electric towers. Radiation can be generally divided into two main categories: ionizing and non-ionizing radiation. These categories are distinguished by the energy of the radiation and its ability to ionize atoms or molecules.

Ionizing Radiation:

Ionizing radiation is a form of high-energy radiation that possesses enough energy to dislodge tightly bound electrons from atoms, resulting in the formation of ions. This process of ionization can cause significant changes in the atomic structure, which can lead to molecular damage, especially in biological tissues. The primary sources of ionizing radiation include radioactive materials, cosmic rays, and certain medical imaging devices. Ionizing radiation is categorized based on its source and interaction with matter into three main types: alpha particles, beta particles, and gamma rays, along with X-rays.

- **Alpha Particles**: Alpha particles consist of two protons and two neutrons, making them relatively large and heavy compared to other forms of radiation. They have a positive charge and are emitted by certain radioactive materials, such as uranium and radium. Due to their size, alpha particles have low penetration power and can be stopped by a sheet of paper or even the outer layer of human skin. However, if alpha-emitting materials are ingested or inhaled, they can cause significant internal damage.
- **Beta Particles**: Beta particles are high-energy, high-speed electrons or positrons emitted by certain types of radioactive nuclei, such as potassium-40. They are much smaller and lighter than alpha particles, allowing them to penetrate further into materials, though they can still be

stopped by materials like plastic or a few millimeters of aluminum. Beta particles can cause skin burns and are hazardous if ingested or inhaled.

- **Gamma Rays and X-Rays**: Gamma rays and X-rays are forms of electromagnetic radiation, similar to light, but with much higher energy. Gamma rays are emitted from the nucleus of radioactive atoms, while X-rays are typically produced by interactions involving electrons. Both have high penetration power and can pass through the human body, making them useful in medical imaging. However, they can also damage living tissues and DNA, potentially leading to cancer.

Application of Ionizing Radiation:

There are a wide range of Ionizing radiation applications, particularly in medicine, industry, and research.

- **Medical Applications**: Medical imaging and cancer treatment has one of the common usage of ionizing radiation application. X-rays are widely used in diagnostic imaging to view inside the body without invasive surgery. Gamma rays are used in radiation therapy to minimize damage to surrounding healthy tissue while damaging the malignant cells.
- **Industrial Applications**: In industry, ionizing radiation is used in processes such as radiography, which involves the use of gamma rays or X-rays to inspect materials for defects without causing damage. Gamma rays are also used to sterilize medical equipment and food products by killing bacteria and other pathogens.
- **Scientific Research**: In research, ionizing radiation is used in various fields, from studying the structure of materials through techniques like X-ray crystallography to investigating the properties of subatomic particles in particle accelerators.
- **Medical Imaging**: X-rays are used in hospitals and clinics worldwide to diagnose broken bones, dental problems, and various internal conditions. A CT scan, which involves multiple images taken from different angles by using an X-ray and it provides detailed images of organs and tissues.
- **Cancer Treatment**: Radiation therapy using gamma rays is a common treatment for various types of cancer. The high-energy radiation targets and destroys cancer cells, helping to shrink tumors and eliminate cancerous growths.

- **Nuclear Power Plants**: In nuclear power plants, ionizing radiation is produced during the fission of uranium atoms. The energy released is used to generate electricity. The radiation is carefully contained, but the potential for exposure remains a significant safety concern.

Effects Of Ionizing Radiation:

Ionizing radiation is characterized by its high energy, which is used to remove closely bounded electrons from atoms and thus creating ions. This process can cause significant molecular and cellular damage. The impact of ionizing radiation on plants, animals, and humans is well-documented and typically severe. In plants, ionizing radiation can disrupt cellular structures and processes in several ways. The DNA within plant cells is particularly vulnerable to damage from ionizing radiation. This can lead to mutations, which may manifest as changes in growth patterns, reduced fertility, or the production of abnormal or stunted offspring. High doses of ionizing radiation can cause direct cellular death, impairing the plant's ability to grow, reproduce, and carry out photosynthesis. This can lead to reduced crop yields in agricultural settings and adversely affect natural ecosystems by reducing biodiversity. In extreme cases, radiation can completely inhibit the growth of plants or lead to widespread die-offs, particularly in areas close to nuclear accidents, where radiation levels are high. For animals and humans, the effects of ionizing radiation are equally, if not more, concerning. Ionizing radiation can penetrate deep into body tissues, where it can damage the DNA within cells. This DNA damage is the root cause of many of the health effects associated with ionizing radiation, including an increased risk of cancer. When the DNA in a cell is damaged, the cell may begin to grow uncontrollably, leading to the formation of tumors. This process can take years or even decades to manifest, which is why cancers related to radiation exposure often do not appear until long after the initial exposure. In addition to cancer, ionizing radiation is also found to be the reason for other health issues, including genetic mutations that can be passed on to future generations, increasing the risk of birth defects. Acute exposure to high levels of ionizing radiation, such as that experienced by the survivors of nuclear explosions or accidents, can lead to a condition known as radiation sickness. Symptoms of radiation sickness include nausea, vomiting, asthma, and a drop in white blood cell count, which can lead to severe infections. In extreme cases, acute radiation exposure can be fatal. Furthermore, specific tissues and organs are more sensitive to ionizing radiation than others. For example, reproductive organs can suffer significant damage, potentially leading to infertility or reduced reproductive success. In pregnant women, exposure to ionizing radiation can result in birth defects or miscarriage. Pregnant women and children are more susceptible to the effects of ionizing radiation due to their rapidly dividing cells, which are more likely to be damaged.

Non-Ionizing Radiation:

Non-ionizing radiation can be defined as radiation that lacks enough energy to ionize atoms or molecules, hence it is unable to release electrons from atoms. Instead of ionizing, non-ionizing radiation primarily causes atoms and molecules to vibrate, leading to the generation of heat or inducing other chemical reactions. Non-ionizing radiation covers a broad range of the electromagnetic spectrum, from extremely low-frequency (ELF) waves to visible light and ultraviolet (UV) light. The primary types of non-ionizing radiation include:

- **Radiofrequency (RF) Radiation**: This type of radiation is commonly associated with communication technologies, including cell phones, Wi-Fi, and broadcasting signals. RF radiation lies in the frequency range from about 3 kHz to 300 GHz and is used to transmit information over long distances. It is non-ionizing and primarily interacts with materials by inducing electric currents and heating them.
- **Microwave Radiation**: Microwaves, a subset of RF radiation, have frequencies between 300 MHz and 300 GHz. They are used in various applications, including microwave ovens, radar systems, and satellite communications. Food is cooked by the heat produced by the interaction of microwaves with the water molecules in it.
- **Infrared (IR) Radiation**: Infrared radiation lies just below visible light in the electromagnetic spectrum, with wavelengths ranging from 700 nanometers to 1 millimeter. It is primarily experienced as heat, and IR radiation is emitted by all objects with a temperature above absolute zero. It is used in applications such as thermal imaging, remote controls, and heating systems.
- **Visible Light**: With wavelengths ranging from around 400 to 700 nanometers, visible light is the part of the electromagnetic spectrum that can be perceived by the human eye. It is essential for vision and is also used in various technologies, from lighting to photography.
- **Ultraviolet (UV) Radiation**: UV radiation lies just above visible light in the electromagnetic spectrum, with wavelengths ranging from 10 to 400 nanometers. While UV radiation is non-ionizing, its higher energy compared to visible light allows it to cause chemical reactions,

such as those that occur in the skin when exposed to sunlight. Overexposure to ultraviolet light can harm the skin and as a result, increase the risk of skin cancer and sunburn.

Application of Non-Ionizing Radiation:

Non-ionizing radiation is ubiquitous in modern life, with applications spanning communication, heating, lighting, and more.

- **Communication Technologies**: RF and microwave radiation are the backbone of modern wireless communication systems. Cell towers, Wi-Fi routers, and broadcasting stations all use these types of radiation to transmit information. In these systems, data is encoded onto electromagnetic waves, which are then transmitted over long distances. Antennas and receivers decode the information, enabling communication.
- **Microwave Ovens**: Food is heated in microwave ovens through microwave radiation. The food's water molecules absorb the microwaves causing them to vibrate and produce heat, which cooks the food. This process is efficient and fast, making microwave ovens a common household appliance.
- **Infrared Technology**: Infrared radiation is used in various applications, from remote controls to thermal imaging. In remote controls, infrared signals are transmitted to control electronic devices like TVs. In thermal imaging, infrared cameras detect the heat emitted by objects, allowing for night vision and heat mapping.
- **Lighting**: Visible light is essential for daily life and is used in everything from natural sunlight to artificial lighting systems. Advances in LED technology have made lighting more energy-efficient, with LEDs emitting light across a broad spectrum.
- **Medical and Cosmetic Applications**: UV radiation is used in medical treatments, such as phototherapy for skin conditions like psoriasis, and in cosmetic applications like tanning beds. However, due to its potential to cause skin damage, the use of UV radiation is carefully controlled.
- **Cell Towers**: Cell towers emit RF radiation to provide wireless communication services. The radiation allows cell phones to connect to the network and communicate with each other. The use of cell towers in a widespread manner has raised concerns about the potential health effects of long-term exposure to RF radiation, especially for those living close to these towers.

- **Microwave Ovens**: Microwave ovens are a common kitchen appliance that uses microwave radiation to cook food quickly. The interaction of microwaves with water molecules in food heats it efficiently, making it a convenient cooking method.
- **Thermal Imaging Cameras**: Infrared cameras are used in various fields, from military applications to building inspections. These cameras detect infrared radiation emitted by objects, allowing them to "see" in the dark or detect heat leaks in buildings.
- **Sunlight**: Sunlight is a natural source of both visible light and UV radiation. While visible light is necessary for vision and plant photosynthesis, excessive UV exposure can lead to skin damage and increase the risk of skin cancer.

Effects Of Non-Ionizing Radiation:

Non-ionizing radiation, while generally less harmful than ionizing radiation, can still pose significant risks to plants, animals, and humans, particularly with long-term or intense exposure. Non-ionizing radiation includes a wide range of electromagnetic radiation, such as ultraviolet (UV) light, radiofrequency (RF) radiation, microwaves, and infrared radiation. Non-ionizing radiation does not directly harm DNA in the same manner as ionizing radiation because it lacks the energy to ionize atoms or molecules. However, it can still cause biological effects through other mechanisms. In plants, non-ionizing radiation, particularly UV radiation, can have both harmful and beneficial effects. UV radiation, which is a component of sunlight, is known to cause DNA damage in plant cells, leading to mutations. These mutations can result in abnormal growth, reduced fertility, and lower rates of photosynthesis, ultimately decreasing the plant's ability to thrive. However, some levels of UV exposure can also stimulate the production of protective compounds, such as flavonoids, which can help the plant defend against further UV damage and even certain pathogens. This dual nature of UV radiation means that while it can be harmful, it also plays a role in regulating certain biological processes in plants. In contrast, RF radiation and microwaves, such as those emitted by cell towers and microwave ovens, typically have less direct impact on plants. However, there is ongoing research into how prolonged exposure to RF radiation may affect plant growth and cellular processes, especially as the use of wireless technology expands. In animals and humans, non-ionizing radiation primarily affects tissues through mechanisms such as heating or photochemical reactions. For instance, exposure to high levels of RF radiation can cause tissue heating, which can lead to thermal damage. This effect is the principle behind how microwave ovens work, where microwaves heat water molecules in food, causing the food to cook. In biological tissues, excessive heating from RF radiation can cause burns or other heat-related injuries. This type of radiation is also emitted by devices like cell phones and Wi-Fi routers, leading to concerns about potential long-term health effects from chronic low-level exposure. Although most studies have not found conclusive evidence linking RF radiation from cell phones to cancer, the World Health Organization (WHO) has classified RF radiation as "possibly carcinogenic to humans," highlighting the need for continued research. UV radiation is another form of non-ionizing radiation that has well-documented effects on both animals and humans. In humans, UV radiation from the sun is a major cause of skin damage, leading to conditions ranging from sunburn to premature aging and skin cancer. The DNA in skin cells can absorb UV light, leading to mutations that can trigger the uncontrolled growth of cells, resulting in skin cancer. The most severe form of skin cancer, melanoma, is strongly associated with UV exposure. UV radiation can also cause damage to the eyes, leading to conditions such as cataracts, which can impair vision. In animals, particularly those with less protective fur or skin, UV radiation can cause similar skin damage and increase the risk of skin cancer. However, many animals have evolved protective behaviors, such as seeking shade during peak sunlight hours, to mitigate these risks.

Differences between Ionizing and Non-Ionizing radiation:

Ionizing and non-ionizing radiation differ primarily in their energy levels and capacities to ionize atoms or molecules. which significantly influences their behavior, penetration power, biological effects, and applications. Ionizing radiation possesses considerably higher energy levels compared to non-ionizing radiation, enabling it to remove tightly bound electrons from atoms, a process known as ionization. This high energy is what makes ionizing radiation particularly dangerous, as it can directly interact with the atoms in living tissues, causing molecular changes that can lead to significant biological damage. X-rays, gamma rays, and some particle types, like alpha and beta particles, are examples of ionizing radiation. Non-ionizing radiation, on the other hand, does not have sufficient energy to ionize atoms. Instead, it interacts with matter in other ways, typically by causing the atoms to vibrate or by generating heat. Ultraviolet (UV), visible, infrared, microwave, and radiofrequency (RF) radiation are examples of this type of radiation. Because non-ionizing radiation lacks the energy to disrupt atomic structures, its effects are generally less severe than those of ionizing radiation, although it can still pose significant risks under certain conditions. The penetration power of ionizing and non-ionizing radiation also differs markedly. Ionizing radiation, due to its high energy, generally has a much greater ability to penetrate materials, including human tissue. For example, gamma rays and X-rays can pass through the human body, allowing them to be used effectively in medical imaging and treatment. This penetration ability is a double-edged sword: while it makes ionizing radiation invaluable in certain applications, it also means that it can reach and damage internal organs and tissues. In contrast, non-ionizing radiation typically has much lower penetration power. Infrared radiation and microwaves, for instance, are usually absorbed by the surface or shallow layers of materials, which limits their ability to penetrate deep into the body. This is why non-ionizing radiation is often considered less hazardous in terms of its ability to cause deep tissue damage, though it can still cause surface-level effects such as burns or heating. When it comes to biological effects, ionizing radiation is far more dangerous due to its ability to ionize atoms and molecules within living cells. This ionization can lead to the formation of free radicals, which are highly reactive molecules that can cause significant damage to cellular components, including DNA. DNA damage is particularly concerning because it can lead to mutations, which in turn can result in cancer or other serious health problems. In high doses, ionizing radiation can also cause acute radiation sickness, characterized by symptoms such as nausea, vomiting, and severe immune system damage. Over time, even low levels of exposure to ionizing radiation can increase the risk of cancer and other health issues, which is why it is carefully regulated in environments where people might be exposed. On the other hand, non-ionizing radiation, while generally less harmful, can still have significant biological effects, especially at high exposure levels or with prolonged exposure. For example, UV radiation from the sun can cause skin damage, accelerate aging, and increase the risk of skin cancer. Other forms of non-ionizing radiation, such as RF radiation from cell phones and microwaves, primarily cause tissue heating. While this heating effect is typically not harmful at the levels encountered in everyday life, there is ongoing research into the potential long-term effects of chronic exposure to low levels of RF radiation, particularly concerning cancer risk. The applications of ionizing and non-ionizing radiation reflect their different properties. Ionizing radiation is primarily used in fields that require high energy levels. In medicine, ionizing radiation is invaluable for diagnostic imaging techniques such as X-rays and CT scans, as well as for the treatment of cancer through radiation therapy. In industry, ionizing radiation is used in processes such as sterilization, where its ability to destroy microorganisms is beneficial. Additionally, ionizing radiation is a key component of nuclear power generation, where it is harnessed to produce electricity. Non-ionizing radiation, in contrast, is ubiquitous in everyday technologies. It is used in communication systems, including radio, television, and mobile phones, where RF radiation carries signals over long distances. Non-ionizing radiation is also used in household devices such as microwave ovens, which cook food by causing water molecules to vibrate and generate heat. UV radiation is employed in various applications, from sterilizing medical equipment to promoting the production of vitamin D in the skin.

In summary, both ionizing and non-ionizing radiation have significant effects on plants, animals, and humans, although the nature and severity of these effects vary widely. Ionizing radiation poses serious risks due to its ability to cause DNA damage, leading to cancer, genetic mutations, and other severe health issues. It can severely affect plants, reducing their growth and reproductive success, and is a significant health hazard for animals and humans, especially at high doses. Non-ionizing radiation, while generally less immediately harmful, can still cause biological effects through mechanisms such as tissue heating and photochemical reactions. UV radiation, a form of non-ionizing radiation, is particularly concerning due to its well-established link to skin cancer and other health problems. As our understanding of these effects deepens, it becomes increasingly important to develop and enforce safety guidelines to minimize the risks associated with exposure to both types of radiation. This is especially critical in the context of the growing use of non-ionizing radiation in communication technologies, which necessitates careful monitoring and ongoing research to ensure public health and environmental safety.

Chapter 04

Tower types

The focus of this chapter lies in understanding two critical infrastructures: cell towers and high-voltage transmission line towers (HVTL), both of which serve vital roles in communication and power distribution. These structures are crucial in modern society, enhancing cellular network coverage and delivering electrical power over vast distances. Despite their importance, both types of towers can have unintended effects on humans, animals, and plants, primarily through non-ionizing radiation. The physical characteristics, positioning strategies (rooftop vs. greenfield), and size variations of these towers are key factors that influence these impacts. Additionally, maintaining a safe distance from these towers is essential for minimizing health risks.

Cell Towers Size Variations

Cell towers, also known as mobile base stations or antenna masts, serve the function of transmitting radio signals to and from mobile devices. Their size can vary significantly, depending on factors like population density, coverage area, and geographical terrain.

- **Small Cell Towers (Microcells):** In densely populated urban environments, cell towers are often smaller, fitting into tighter spaces with high data demand. These microcell towers range from 20 to 30 feet (6 to 9 meters) in height. They are designed to provide targeted coverage to areas with significant user congestion, like shopping malls, downtown areas, or sports arenas. Their smaller size ensures they blend into the landscape, often camouflaged as lampposts or street signs.
- **Medium-Size Towers (Macrocells):** Macrocells are more substantial, typically found in suburban or semi-urban environments, where coverage areas are larger, but population density is lower than in urban centers. These towers can be around 50 to 150 feet (15 to 45 meters) tall. They are usually free-standing structures and are built with the capacity to cover more extensive geographical areas than microcells.
- **Large Cell Towers:** In rural areas, where population density is low but coverage areas are large, the most prominent cell towers, known as macrocell towers, can exceed 200

feet (60 meters) in height. These structures are necessary to cover vast areas with fewer towers, providing sufficient coverage across farmlands, forests, and remote areas.

Cell Tower Positioning: Rooftop vs. Greenfield

The positioning of cell towers is closely linked to their surrounding environment, purpose, and regional geography. Typically, cell towers are categorized into rooftop towers and greenfield towers, depending on where they are installed.

- **Rooftop Towers:** In urban environments where space is limited, cell towers are often placed on rooftops. Rooftop towers offer several advantages, including the ability to take advantage of existing structures to achieve the necessary height for optimal signal transmission. These towers are typically smaller than greenfield towers, making them less visually intrusive in densely populated areas. Rooftop towers provide critical coverage in areas where high-rise buildings can obstruct signals.

Figure 2: Rooftop Cell Tower

By placing the tower on the rooftop of tall buildings, network providers can ensure that the signal reaches a wide area without interference. These towers are strategically positioned to cover densely populated regions where there is a high demand for mobile services. The installation of rooftop towers, however, comes with challenges. In addition to structural concerns regarding weight and wind load, there are health-related concerns due to the proximity of these towers to people living or working in the buildings where the towers are installed. While the radiation emitted by cell towers is generally considered safe, prolonged exposure to non-ionizing radiation has raised concerns, especially in cases where towers are situated close to living spaces.

- **Greenfield Towers:** Greenfield towers, on the other hand, are independent structures typically placed in open areas. These towers are commonly found in suburban or rural regions where there is ample space to construct larger, more prominent towers.

Figure 3: Green Field Cell Tower

Greenfield towers are often built to cover large geographical areas with fewer installations, as their height and open location allow them to transmit signals over greater distances. Greenfield sites are ideal for areas where population density is low, and space is abundant. These towers can be as tall as 300 feet (90 meters) or more, depending on the specific needs of the network provider. The open location of these towers allows for more extensive coverage, making them a cost-effective solution for providing connectivity in sparsely populated regions. While greenfield towers are less likely to be located near residential areas, they still pose environmental concerns. The construction of these towers can disrupt local ecosystems, and the non-ionizing radiation they emit can affect nearby plants and animals. Additionally, the visual impact of these towers on the landscape is a consideration, as they are often much taller and more noticeable than rooftop towers.

High Voltage Transmission Line Towers: Size Variations

High-voltage transmission line towers (HVTL) are built to move electricity across vast distances, connecting power plants to substations and, eventually, to consumers. The size of these towers depends on the voltage they transmit and the spacing between them.

- **Standard Transmission Towers:** Standard transmission towers, which carry high-voltage lines, are typically between 49 and 180 feet (15–55 meters) tall. These towers are designed to provide the necessary clearance for the high-voltage lines, ensuring that they are safely distanced from the ground and nearby structures. The height of these towers also helps to prevent electrical interference from other nearby electrical components. Transmission towers are often built in a straight line, with spacing between them varying based on the voltage of the lines and the terrain. In flat, open areas, the spacing between towers can be greater, while in more rugged terrain, the towers may need to be placed closer together.
- **Ultra-High Voltage Towers:** In cases where ultra-high-voltage lines are used, the towers can reach heights of up to 500 feet (150 meters) or more. These towers are designed to carry extremely high voltages over long distances, often between power plants and major substations. The increased height of these towers helps to decrease the risk of electrical hindrance and ensures that the lines are safely distanced from the ground and surrounding structures. Ultra-high-voltage towers are typically found in rural or industrial areas, as the size and height of these towers make them unsuitable for placement in urban environments. However, in some cases, such as in developing countries where infrastructure planning may be less organized, these towers can be found in urban areas.

High Voltage Transmission Line Towers Positioning: Rooftop vs. Greenfield

- **Rooftop Transmission Towers:** Rooftop transmission towers are uncommon, but in some cases, particularly in densely populated urban areas, high-voltage lines may be routed across rooftops. This practice is generally avoided due to the safety risks associated with placing high-voltage lines in close proximity to residential or commercial buildings. When rooftop transmission towers are used, they are typically much smaller than greenfield towers, and the voltage of the lines they carry is lower. These towers are usually found in densely populated areas where there is no room for traditional greenfield towers, and they are often installed as a last resort to ensure that power can be delivered to areas with limited space. The safety risks associated with rooftop transmission towers are significant, as high-voltage lines emit electromagnetic fields (EMFs) that can affect nearby living beings. Prolonged exposure to EMFs has been linked to a variety of health concerns, particularly for people living or working in close proximity to these towers.
- **Greenfield Transmission Towers:** Greenfield transmission towers are the most common type of tower used for high-voltage lines. These towers are typically placed in open areas, away from residential and commercial buildings, to minimize the risk of electrical interference and ensure the safety of nearby populations.

Figure 4: High Voltage Transmission Line

Greenfield towers are often placed in rural or industrial areas, where there is ample space to construct large towers and where the risk to nearby living beings is minimized.

Figure 5: Greenfield High Voltage Transmission Line

The placement of greenfield transmission towers is carefully planned to ensure that the towers are located at a safe distance from any nearby populations. In general, high-voltage transmission towers should be placed at least 200 meters away from residential areas to minimize the risk of exposure to electromagnetic fields. For ultra-high-voltage towers, this distance may be even greater.

Safe Distances for Towers: Plants, Animals, and Humans

The safe distance of towers from living beings is a critical consideration in the placement of both cell towers and high-voltage transmission towers. The non-ionizing radiation emitted by these towers can affect plants, animals, and humans, particularly when exposure is prolonged or when the towers are placed in close proximity to residential areas.

- **Humans:** For cell towers, a minimum safe distance of 100 to 500 meters (328 to 1,640 feet) from residential areas is often recommended to reduce exposure to non-ionizing radiation. Rooftop towers should be placed at least 10 meters (33 feet) above the topmost floor of a building to reduce the radiation impact on inhabitants. For high-voltage transmission towers, safe distance guidelines recommend keeping residential areas at least 500 meters (1,640 feet) away to minimize the risk of EMF exposure.
- **Animals:** Studies have shown that prolonged exposure to electromagnetic fields from both cell towers and HVTLs can have adverse effects on animals, including changes in behavior, reproduction, and overall health. Farm animals, in particular, are sensitive to high levels of radiation, and therefore, towers should be positioned at a safe distance of at least 500 meters from areas where animals are kept.
- **Plants:** The study of non-ionizing radiation's impact on plants is still developing. Some studies suggest that electromagnetic fields may alter plant growth and photosynthesis. While the impact is not as pronounced as in animals or humans, a buffer zone of 100 to 200 meters is often suggested to prevent any potential disruption to plant ecosystems, especially in agricultural areas.

Understanding the size, positioning, and safe distances for cell towers and high-voltage transmission towers is crucial in minimizing their potential risks to humans, animals, and plants. While these towers serve essential functions in communication and power distribution, maintaining proper installation standards and safe distances can help mitigate any negative impacts of non-ionizing radiation emitted from these structures.

Chapter 05

Field Types

Electromagnetic fields (EMFs) are an integral part of our environment, especially with the increasing prevalence of electronic devices, communication technologies, and power infrastructure.

Figure 6: Quantitative data from direct EMF measurements

These fields arise wherever electricity is used, generated, or transmitted, and they encompass a range of frequencies and types, each with different characteristics and potential impacts on living organisms. This chapter delves into the various types of fields associated with non-ionizing radiation, focusing on electric fields, magnetic fields, and radiofrequency (RF) fields, all of which are relevant to the operation of cell towers and high-voltage transmission lines. Understanding these fields' nature, how they work, and their potential effects on plants, animals, and humans is crucial for assessing the broader implications of modern technological infrastructures. Electromagnetic fields (EMF) are a physical phenomenon produced by electrically charged objects. EMF consists of two components: electric fields, which are generated by stationary charges, and magnetic fields, which are produced by moving charges or currents. The combination of these fields propagates as electromagnetic waves, covering a spectrum that includes both non-ionizing and ionizing radiation. Non-ionizing radiation, which includes EMFs from cell towers and high-voltage transmission lines, lacks the energy necessary for atoms or molecules to ionize but can still interact with biological tissues in ways that may have health implications.

Electric Fields:

Electric fields are a fundamental aspect of electromagnetic phenomena, generated whenever there is a stationary electric charge or a voltage difference across a conductor. Unlike magnetic fields, which only exist when there is a flow of electric current, electric fields can be present even when no current is flowing, provided there is a voltage present. These fields are an intrinsic part of the environment around electrical systems, and their strength is quantified in volts per meter (V/m). The intensity of an electric field is directly proportional to the voltage: the higher the voltage, the stronger the electric field. Electric fields exert forces on charged particles, such as electrons and ions, within the field. This force influences the movement and behavior of these particles, which can have significant implications in various contexts, particularly in biological systems. **According to The International Commission on Non-Ionizing Radiation Protection (ICNIRP) the Optimum Range of Exposure of Electric field for Cell Tower is 0.5 V/m to 5 V/m. And for High Voltage Transmission Line is 1 kV/m to 10 kV/m.** In biological tissues, electric fields can alter the distribution of ions across cell membranes, potentially affecting cellular processes such as signal transmission in nerve cells or the regulation of cell functions. One of the critical characteristics of electric fields is that their strength diminishes rapidly with distance from the source. This attenuation follows the inverse square law, meaning that the field strength is inversely proportional to the square of the distance from the source. For example, if you double the distance from the source, the electric field strength decreases by a factor of four. This rapid decline means that electric fields from a source, such as a high-voltage transmission line or an electrical appliance, become weaker the farther you move away from the source. Another important aspect of electric fields is that they are relatively easy to shield. Conductive materials, such as metal, can effectively block or attenuate electric fields. This shielding capability is why buildings, vehicles, and other structures often have reduced electric field levels inside compared to the outside environment. For instance, in a building with metal structural components or a grounded electrical system, the electric fields from external sources like power lines are significantly diminished inside the building.

Magnetic Fields:

Magnetic fields are a crucial component of electromagnetic phenomena, generated by the movement of electric charges, such as those in a current-carrying wire. Unlike electric fields, which exist in the presence of voltage even without current, magnetic fields only arise when there is a flow of electric current. This relationship between current and magnetic fields is fundamental to the operation of many electrical devices and systems, including those found in everyday life and industrial settings. Magnetic fields are measured in units of tesla (T), with more common measurements in micro Tesla (μT) or milligauss (mG). For perspective, the Earth's magnetic field at its surface is about 50 μT or 500 mG. In contrast, the fields generated by household appliances, power lines, or industrial equipment can vary widely but are generally much weaker. **According to The International Commission on Non-Ionizing Radiation Protection (ICNIRP) the Optimum Range of Exposure of Magnetic field for Cell Tower is below 0.1 milligauss (mG). And for High Voltage Transmission Line is 1 milligauss (mG) to 200 milligauss (mG).** The generation of magnetic fields is intrinsically linked to the flow of electric current. According to Ampère's Law, any flow of electric charge, or current, through a conductor generates a magnetic field around that conductor. The strength of this magnetic field is directly proportional to the current’s intensity; higher currents produce stronger magnetic fields. For example, in a simple straight wire, the magnetic field forms concentric circles around the wire. The direction of the magnetic field follows the "right-hand rule": if you point the thumb of your right hand in the direction of the current, your fingers curl in the direction of the magnetic field lines. Magnetic fields exert forces on other moving charges within their influence, a phenomenon that is foundational to the operation of devices like electric motors and generators. In biological tissues, these fields can induce electric currents, particularly in conductive tissues like nerves and muscles. These induced currents can influence cellular processes, potentially affecting functions like nerve signaling and muscle contraction. One of the critical characteristics of magnetic fields is their ability to penetrate most materials, including biological tissues. This makes magnetic fields more challenging to shield than electric fields. While materials such as iron or other ferromagnetic substances can provide some degree of shielding by redirecting magnetic field lines, most non-magnetic materials, including human tissue, offer little resistance to the passage of magnetic fields.

Radio Frequency:

Radiofrequency (RF) fields are a type of non-ionizing radiation within the electromagnetic spectrum, occupying a frequency range from **According to The International Commission on Non-Ionizing Radiation Protection (ICNIRP), 1998; 1kHz to 300 GHz. In these frequencies the Optimum Range of Exposure of RF Strength for Cell Tower is below 45 µW/m^2, and the High Voltage Transmission Line is around 0.0000265 µW/m^2.** These frequencies are extensively utilized in modern wireless communication technologies, including mobile phones, Wi-Fi, radio, and television broadcasting. RF fields are essential for transmitting information over long distances by modulating various properties of electromagnetic waves, such as amplitude, frequency, or phase. Unlike ionizing radiation (e.g., X-rays or gamma rays), which has enough energy to remove tightly bound electrons from atoms, RF fields do not carry enough energy to ionize atoms or molecules. Instead, RF fields interact with matter in ways that can lead to thermal and non-thermal effects, making them a key focus of both technological applications and health studies. RF fields are capable of traveling long distances, making them ideal for communication purposes. The propagation of RF fields depends on factors such as frequency, power, and environmental conditions. At lower frequencies, RF fields can travel over the horizon due to their ability to diffract around obstacles and reflect off the ionosphere. Higher frequencies, such as those used in microwave and millimeter-wave communications, generally travel in straight lines and are more susceptible to absorption and reflection by materials like buildings, trees, and atmospheric gases. The ability of RF fields to carry information is based on the modulation of the wave's properties. In Amplitude Modulation (AM), the amplitude (strength) of the RF wave varies in proportion to the information signal, such as a voice or data. This method is widely used in AM radio broadcasting. In Frequency Modulation (FM), the frequency of the RF wave is varied according to the information signal. FM is commonly used in FM radio broadcasting and certain types of wireless communication because it offers better noise resistance than AM. Phase Modulation (PM) involves varying the phase of the RF wave with the information signal. It is used in various digital communication systems, including some forms of Wi-Fi and cellular technology.

The Relationship of Electric, Magnetic, and Radiofrequency Fields with High-Voltage Transmission Lines and Cell Towers:

High-voltage transmission lines and cell towers are critical components of modern infrastructure, enabling the delivery of electricity and telecommunications services. However, they are also significant sources of various types of electromagnetic fields (EMFs), including electric fields, magnetic fields, and radiofrequency (RF) fields. Understanding the characteristics, strengths, and potential health implications of these fields is essential for assessing the safety and environmental impact of these structures. High-voltage transmission lines are designed to transport large amounts of electrical energy over vast distances, typically at voltages ranging from 110 kV to 765 kV or more. Due to the high voltages involved, these transmission lines generate strong electric fields in their vicinity. The strength of the electric field is directly related to the voltage carried by the line and is typically strongest directly beneath the conductors. As the distance from the transmission line increases, the electric field strength decreases rapidly, following an inverse square law in open space. The electric fields produced by high-voltage transmission lines can influence nearby objects, causing them to become electrically charged. This phenomenon can be observed when objects such as vehicles or fences near transmission lines develop a slight charge, which may lead to a mild shock upon contact, especially in dry conditions. However, the strength of the electric field at ground level is usually well within the safety limits set by regulatory bodies, although there is ongoing research into the long-term exposure effects on human health. Cell towers, unlike high-voltage transmission lines, primarily serve the purpose of transmitting and receiving wireless communication signals. These towers generate electric fields as a result of the power output of the antennas, which are designed to broadcast signals over large areas to maintain network coverage. The electric field strength generated by cell towers is generally much weaker than that produced by high-voltage transmission lines. This is because the voltage involved in cellular transmission is significantly lower, typically in the range of a few volts to tens of volts. The intensity of the electric field emitted by a cell tower depends on factors such as the power output of the antenna, the design of the tower, and the distance from the source. The electric field strength decreases with distance from the tower, and the design of the antenna is often optimized to direct the signal horizontally rather than vertically, reducing exposure to the ground level. Magnetic fields are generated by the flow of electric current through conductors. High-voltage transmission lines, which carry large current loads, are significant sources of magnetic fields. The strength of the magnetic field is directly proportional to the current carried by the line and is strongest directly beneath the conductors. Unlike electric fields, magnetic fields are not influenced by the voltage of the line but by the amount of current. The magnetic fields generated by transmission lines can extend several meters from the source, creating a zone of influence around the lines. These fields are of particular concern in studies on potential health effects, as they can be more persistent and widespread than electric fields. While regulatory bodies have established exposure limits for magnetic fields, ongoing research continues to investigate the potential links between long-term exposure to these fields and health issues such as childhood leukemia and other forms of cancer. In contrast to transmission lines, cell towers generate relatively weak magnetic fields. The primary sources of magnetic fields in cell towers are the electronic equipment housed at the base, such as power supplies, transformers, and signal processing equipment. The antennas themselves, which are responsible for transmitting RF signals, do not generate significant magnetic fields. The magnetic fields associated with cell towers are typically confined to the immediate vicinity of the equipment and are much weaker than those generated by high-voltage transmission lines. As a result, magnetic fields from cell towers are generally not considered a significant health concern, although there is still some debate and ongoing research regarding the cumulative effects of exposure to weak magnetic fields in combination with other types of EMFs. Cell towers are major sources of radiofrequency (RF) fields, which are used to transmit wireless communication signals, including voice, data, and video. These towers are designed to cover wide areas, providing network coverage to millions of users. The RF fields emitted by cell towers are typically strongest at the base of the tower and decrease with distance and height. The antennas are usually mounted on tall structures to maximize coverage and minimize interference from buildings and other obstacles. The design and placement of cell towers are carefully planned to ensure that the RF fields are directed primarily towards the intended coverage area while minimizing unnecessary exposure to populated areas. Regulatory bodies have established guidelines for RF exposure, setting limits to protect public health. These limits are based on the power density of the RF field, which decreases rapidly with distance from the source. While the RF fields from cell towers are generally considered safe within these limits, there is ongoing research into the potential long-term health effects of chronic exposure, particularly in relation to the development of conditions such as cancer, neurological disorders, and electromagnetic hypersensitivity. While high-voltage transmission lines are primarily sources of electric and magnetic fields, they can also emit low-level RF fields, particularly at very high voltages. These RF fields are generally much weaker than those produced by cell towers and are not typically considered a significant source of RF exposure. The RF emissions from transmission lines are primarily due to corona discharge, a phenomenon that occurs when the electric field around a conductor is strong enough to ionize the surrounding air, creating a small amount of RF radiation. The RF fields associated with transmission lines are usually limited to the immediate vicinity of the lines and decrease rapidly with distance. Although these fields are not typically a cause for concern, they are still subject to regulatory oversight, and ongoing research continues to monitor the potential health impacts of exposure to low-level RF fields from transmission lines. The relationship between electric, magnetic, and radiofrequency fields in high-voltage transmission lines and cell towers is complex and multifaceted. Each type of structure generates different types of electromagnetic fields with varying strengths and characteristics. High-voltage transmission lines are significant sources of both electric and magnetic fields, with the potential to influence the environment and human health. Cell towers, on the other hand, are major sources of RF fields, essential for modern communication but also a subject of ongoing research regarding their long-term health effects.

Chapter 06

Effects on Plants, Animals, and Humans

Electric fields interact with living organisms by influencing the distribution of ions and the movement of electrically charged particles within tissues. In plants, strong electric fields can affect growth patterns, potentially altering cell division and elongation. In animals and humans, prolonged exposure to high electric fields might cause nerve and muscle stimulation, though these effects typically require field strengths far greater than those encountered near most transmission lines and cell towers. In residential areas, where electric fields from these sources are generally low, the effects are minimal, often overshadowed by other environmental factors. Electric fields also play a role in agricultural settings and the natural environment, where they can influence the growth and behavior of plants and animals. Some studies have shown that electric fields can influence plant growth, particularly in controlled environments. For example, certain field strengths can stimulate seed germination or affect the rate of cell division in plants. These effects are highly variable and depend on factors such as field strength, plant species, and exposure duration. Animals, particularly those with heightened sensitivity to electromagnetic fields, such as birds and insects, may be influenced by electric fields. However, the electric fields generated by human-made sources like power lines are generally weak compared to natural sources, such as the Earth's static electric field, and the impact on animals is typically minimal.

The health implications of electric field exposure are a subject of ongoing research and debate. At typical environmental levels—such as those near household appliances or under transmission lines—there is no strong evidence to suggest that electric fields pose significant health risks. However, at very high levels, electric fields can induce currents in the body that might interfere with biological processes. Extremely strong electric fields, such as those encountered in industrial settings or very close to high-voltage transmission lines, can cause nerve and muscle stimulation. This phenomenon occurs because the electric field induces currents in the body, which can mimic the electrical signals that nerves use to communicate. However, such effects require field strengths much higher than those typically encountered in everyday life. To protect public health, many countries have established regulatory limits on electric field exposure. These limits are designed to prevent harmful effects and are based on extensive research. For example, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) sets guidelines for maximum exposure levels.

Magnetic fields have been studied extensively for their biological effects. In plants, magnetic fields can influence growth patterns and seed germination, though the exact mechanisms remain poorly understood. In animals, magnetic fields can affect navigation and migration behaviors, particularly in species that rely on the Earth's magnetic field for orientation. In humans, there has been concern about the potential link between prolonged exposure to magnetic fields and certain health conditions, such as cancer and neurodegenerative diseases.

Figure 7: Habitats located dangerously close to cell towers in the city of Chittagong

However, the evidence remains inconclusive, and many studies suggest that everyday exposure levels, such as those encountered near transmission lines, are generally safe. Magnetic fields have been extensively studied for their potential health effects, given their ability to penetrate biological tissues and induce currents. Short-term exposure to strong magnetic fields, such as those near industrial equipment or MRI machines, can induce currents in the body that might cause acute effects. Extremely strong magnetic fields can induce currents in nerves and muscles, leading to involuntary contractions or sensations. These effects are typically only observed in fields much stronger than those encountered in everyday environments, such as inside an MRI machine or near industrial electromagnets. The potential long-term health effects of exposure to lower levels of magnetic fields, such as those generated by power lines or household appliances, are still a subject of ongoing research. One of the most studied potential effects is the link between magnetic field exposure and cancer, particularly childhood leukemia. Some epidemiological studies have suggested a possible association between prolonged exposure to magnetic fields and an increased risk of leukemia, though the evidence is not conclusive. The World Health Organization (WHO) and other health authorities continue to monitor and review the scientific evidence on this topic. Another area of research is the potential link between magnetic field exposure and neurodegenerative diseases, such as Alzheimer's and Parkinson's disease. Some studies have suggested that long-term exposure to low-level magnetic fields could contribute to the development of these conditions, but the evidence is still preliminary.

The effects of RF fields on biological systems have been a topic of intense study, particularly concerning the proliferation of mobile phones and wireless networks. In plants, RF fields have been observed to influence growth and development, with some studies reporting changes in cellular structures and metabolic processes. In animals, RF exposure can affect behavior, reproduction, and, in some cases, DNA integrity, though these effects are usually associated with higher exposure levels than those typical of environmental sources like cell towers. In humans, the potential health impacts of RF exposure, particularly in relation to cancer and other chronic conditions, have been the subject of extensive research. While some studies suggest a possible link between prolonged RF exposure and certain health risks, the consensus from organizations like the World Health Organization (WHO) is that typical environmental exposure levels from sources like cell towers do not pose significant health risks. However, ongoing research is necessary to fully understand the long-term effects of low-level RF exposure. The primary health concern associated with RF field exposure is related to thermal effects, where the energy from the RF field is absorbed by the body and converted into heat. The most direct thermal effect of RF exposure is localized heating in the tissues closest to the source. For example, using a mobile phone held against the ear can cause a slight increase in the temperature of the skin and underlying tissues. However, regulatory standards for mobile phones ensure that the SAR remains below levels that could cause significant heating. In environments with high-power RF fields, such as near powerful broadcast transmitters or industrial RF equipment, there is a potential for whole-body heating. This is particularly relevant in occupational settings, where workers may be exposed to higher levels of RF fields over extended periods. Safety guidelines and exposure limits are in place to prevent harmful levels of whole-body heating. In addition to thermal effects, there has been ongoing research into potential non-thermal effects of RF field exposure, which could occur at levels below those that cause significant heating. One of the most studied potential non-thermal effects is the risk of cancer, particularly brain tumors in relation to mobile phone use. Some epidemiological studies have suggested a possible association between heavy mobile phone use and certain types of brain tumors, such as gliomas and acoustic neuromas. However, the evidence is not conclusive, and many studies have found no significant link. The International Agency for Research on Cancer (IARC) has classified RF fields as "possibly carcinogenic to humans" (Group 2B), indicating that there is limited evidence for this risk. Some individuals report experiencing symptoms such as headaches, fatigue, and dizziness when exposed to RF fields, a condition often referred to as electromagnetic hypersensitivity (EHS). However, scientific studies have not found consistent evidence linking these symptoms to RF exposure, and the condition remains a controversial topic. Electric, magnetic, and RF fields interact with biological tissues in different ways. Electric fields influence the distribution of ions and charged particles, which can affect cellular processes but are generally easy to shield. Magnetic fields induce currents within tissues, potentially influencing nervous and muscular systems, and are more challenging to shield. RF fields primarily cause dielectric heating, which can influence tissue temperature and potentially affect cellular structures and functions. The distribution of these fields in the environment depends on the source and the surrounding infrastructure. High-voltage transmission lines produce strong electric and magnetic fields that extend into the surrounding area, with the potential to influence both human health and ecological systems. Cell towers, while primarily sources of RF fields, also emit electric and magnetic fields, though at lower intensities. The environmental impact of these fields is influenced by factors such as the distance from the source, the power output, and the presence of shielding materials. Regulations governing exposure to EMF vary by country and are designed to protect public health by limiting exposure to levels that are considered safe. For electric and magnetic fields, exposure limits are typically set based on the potential for acute effects, such as nerve stimulation or tissue heating. For RF fields, exposure limits are based on preventing tissue heating and minimizing the risk of long-term health effects. These regulations are informed by ongoing research and are periodically updated to reflect new scientific findings

Chapter 07

METHODOLOGY

This study of EFFECTS OF NON-IONIZING RADIATION OF CELL TOWER (CT) AND HIGH VOLTAGE TRANSMISSION LINE (HVTL) ON PLANTS, ANIMALS AND HUMANS utilized a survey-based research approach to investigate the electromagnetic field (EMF) emissions from cell towers and high-voltage transmission power lines (HVTL) in various districts of Bangladesh. By focusing on real-time data collection from visiting both cell towers and HVTL towers, with survey questionnaires, the research aimed to analyze the intensity of electric fields, magnetic fields, and radio frequency (RF) emissions from these infrastructures, as well as assess their potential health impacts on the general masses.

Figure 8: Measuring the strength of the electric and magnetic fields of radiation emitted by a typical household cellular tower

Survey-Based Research Approach

The study adopted a survey-based methodology, gathering quantitative data from direct EMF measurements at selected sites and qualitative data through participant questionnaires. The survey aimed to capture perceptions of generals regarding exposure to electromagnetic fields, electric field and radio frequency to human health and environment and also allowed the study to combine objective data from EMF measurements with subjective experiences reported by individuals in the vicinity of cell towers and power lines.

Quantitative data was gathered using specialized EMF devices, which measured the levels of electric fields, magnetic fields, and radio frequency emissions in real time at selected sites. These sites were strategically chosen to include both urban and rural areas where cell towers and HVTLs were present. The goal was to capture accurate, real-time data on the intensity of emissions, enabling a detailed analysis of how these emissions varied across different environments and distances from the towers. In parallel, **qualitative data** was collected through surveys administered to participants living or working in the areas near the towers and power lines. The survey included questions aimed at capturing participants' perceptions of their exposure to EMF emissions, any health concerns they may have experienced, and demographic information such as age, occupation, and proximity to the towers. This qualitative data allowed the researchers to understand how individuals perceived the risks associated with electromagnetic radiation and whether they had noticed any health symptoms they attributed to their proximity to these sources. By combining these two types of data, the study was able to provide a more holistic view of the issue. The quantitative measurements offered an objective, scientifically grounded assessment of EMF exposure levels, while the qualitative responses helped contextualize these findings within the lived experiences and concerns of the affected populations. This mixed-method approach enabled the research to not only quantify the emissions but also to explore potential links between exposure and health, as perceived by individuals in the community. This comprehensive approach provided a robust framework for assessing both the technical aspects of EMF exposure and its potential human impact. By using both types of data, the study gave a more complete picture of the issue. The quantitative measurements provided clear, scientific information about EMF exposure levels, while the qualitative responses added context by reflecting the real-life experiences and concerns of the people living near the towers. This combined approach helped us not only measure the EMF emissions but also explore possible connections between exposure and health issues, as described by the community. This method gave a strong foundation for understanding both the technical side of EMF exposure and its potential effects on people's health.

Utilization of Electromagnetic Field (EMF) Device

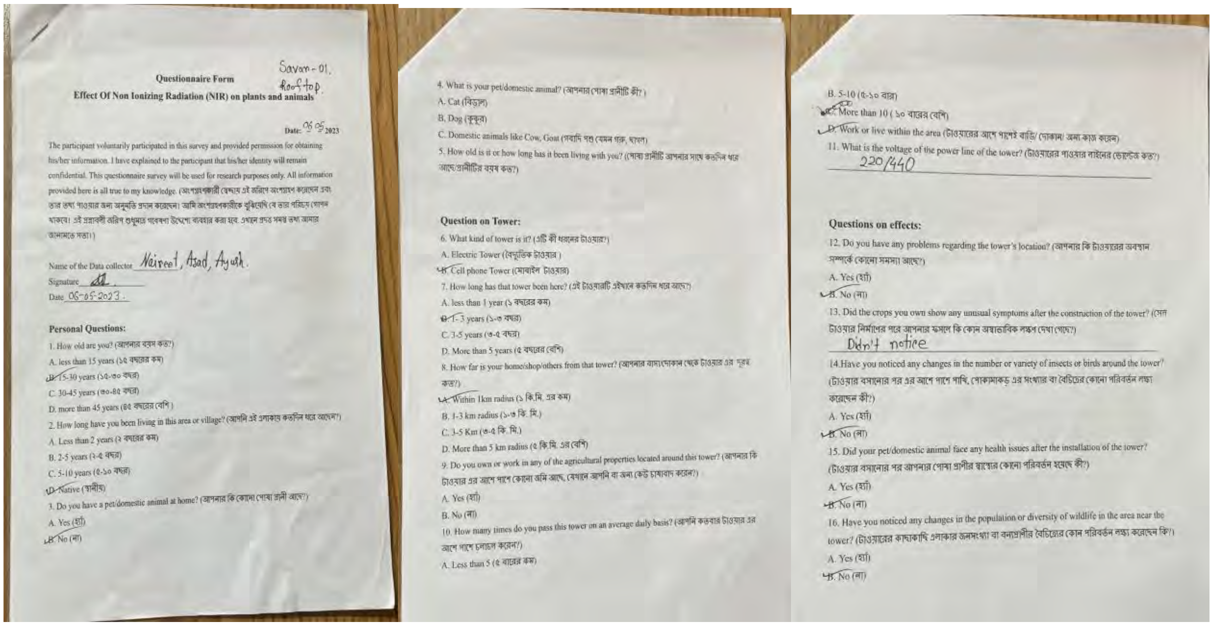
Specialized EMF measurement devices were employed to measure electric field, magnetic field, and radio frequency emissions in real time. These devices recorded the intensity of emissions at various distances from the towers, providing precise measurements of electromagnetic radiation levels emitted by both cell towers and HVTL structures.

Figure 9: EMF Device

Real-time data acquisition enabled the identification of peak field strengths and fluctuations over time, ensuring a comprehensive understanding of the emissions. The measurements captured variations in field intensities and allowed for accurate comparison against national and international safety standards.

Questionnaire for Personalized Health Data

To complement the quantitative EMF data, the study administered a structured questionnaire to residents living near the towers. The questionnaire gathered personalized health-related information, such as symptoms, health status, lifestyle habits, and the proximity of their residence to the towers or power lines.


Savan-01.
Roof top.
Questionnaire Form
Effect Of Non Ionizing Radiation (NIR) on plants and animals
Date: 06 05 2023
The participant voluntarily participated in this survey and provided permission for obtaining his/her information. I have explained to the participant that his/her identity will remain confidential. This questionnaire survey will be used for research purposes only. All information provided here is all true to my knowledge.
Name of the Data collector Naireet, Asad, Ayush.
Signature
Date 06-05-2023.

Personal Questions:
1. How old are you? (আপনার বয়স কত?)
A. less than 15 years (১৫ বছরের কম)
B. 15-30 years (১৫-৩০ বছর)
C. 30-45 years (৩০-৪৫ বছর)
D. more than 45 years (৪৫ বছরের বেশি)
2. How long have you been living in this area or village?
A. Less than 2 years (২ বছরের কম)
B. 2-5 years (২-৫ বছর)
C. 5-10 years (৫-১০ বছর)
D. Native (স্থানীয়)
3. Do you have a pet/domestic animal at home?
A. Yes (হ্যাঁ)
B. No (না)
4. What is your pet/domestic animal?
A. Cat (বিড়াল)
B. Dog (কুকুর)
C. Domestic animals like Cow, Goat
5. How old is it or how long has it been living with you?

Question on Tower:
6. What kind of tower is it?
A. Electric Tower (বৈদ্যুতিক টাওয়ার)
B. Cell phone Tower (মোবাইল টাওয়ার)
7. How long has that tower been here?
A. less than 1 year (১ বছরের কম)
B. 1-3 years (১-৩ বছর)
C. 3-5 years (৩-৫ বছর)
D. More than 5 years (৫ বছরের বেশি)
8. How far is your home/shop/others from that tower?
A. Within 1km radius
B. 1-3 km radius
C. 3-5 Km
D. More than 5 km radius
9. Do you own or work in any of the agricultural properties located around this tower?
A. Yes (হ্যাঁ)
B. No (না)
10. How many times do you pass this tower on an average daily basis?
A. Less than 5
B. 5-10
C. More than 10
D. Work or live within the area
11. What is the voltage of the power line of the tower?
220/440

Questions on effects:
12. Do you have any problems regarding the tower's location?
A. Yes (হ্যাঁ)
B. No (না)
13. Did the crops you own show any unusual symptoms after the construction of the tower?
Didn't notice
14. Have you noticed any changes in the number or variety of insects or birds around the tower?
A. Yes (হ্যাঁ)
B. No (না)
15. Did your pet/domestic animal face any health issues after the installation of the tower?
A. Yes (হ্যাঁ)
B. No (না)
16. Have you noticed any changes in the population or diversity of wildlife in the area near the tower?
A. Yes (হ্যাঁ)
B. No (না)

Figure 10: Questionnaire Form

These responses provided valuable qualitative data, enabling us to explore potential correlations between EMF exposure and reported health conditions. The inclusion of this subjective data enriched the study by providing insights into individual experiences and concerns related to electromagnetic radiation.

Below is the sample of the **Questionnaire Form** that was used to complement the Quantitative EMF data.

QUESTIONNAIRE FORM.

EFFECTS OF NON-IONIZING RADIATION OF CELL TOWER (CT) AND HIGH VOLTAGE TRANSMISSION LINE (HVTL) ON PLANTS, ANIMALS AND HUMANS.

Date:

The participant voluntarily participated in this survey and provided permission for obtaining his/her information. I have explained to the participant that his/her identity will remain confidential. This questionnaire survey will be used for research purposes only. All information provided here is all true to my knowledge. (অংশগ্রহণকারী স্বেচ্ছায় এই

জরিপে অংশগ্রহণ করেছেন এবং তার তথ্য পাওয়ার জন্য অনুমতি প্রদান করেছেন। আমি অংশগ্রহণকারীকে বুঝিয়েছি যে তার পরিচয় গোপন থাকবে। এই প্রশ্নাবলী জরিপ শুধুমাত্র গবেষণা উদ্দেশ্যে ব্যবহার করা হবে. এখানে প্রদত্ত সমস্ত তথ্য আমার জানামতে সত্য।)

Name of the Data collector____________

Signature_________________

Date_________________

Personal Questions:

1. How old are you? (আপনার বয়স কত?)

A. less than 15 years (১৫ বছরের কম)

B. 15-30 years (১৫-৩০ বছর)

C. 30-45 years (৩০-৪৫ বছর)

D. more than 45 years (৪৫ বছরের বেশি)

2. How long have you been living in this area or village? (আপনি এই এলাকায় কতদিন ধরে আছেন?)

A. Less than 2 years (২ বছরের কম)

B. 2-5 years (২-৫ বছর)

C. 5-10 years (৫-১০ বছর)

D. Native (স্থানীয়)

3. Do you have a pet/domestic animal at home? (আপনার কি কোনো পোষা প্রানী আছে?)

A. Yes (হ্যাঁ)

B. No (না)

4. What is your pet/domestic animal? (আপনার পোষা প্রানীটি কী?)

A. Cat (বিড়াল)

B, Dog (কুকুর)

C. Domestic animals like Cow, Goat (গবাদি পশু যেমন গরু, ছাগল)

5. How old is it or how long has it been living with you? (পোষা প্রানীটি আপনার সাথে কতদিন ধরে আছে/প্রানীটির বয়ষ কত?)

Question on Tower:

6. What kind of tower is it? (এটি কী ধরনের টাওয়ার?)

A. Electric Tower (বৈদ্যুতিক টাওয়ার)

B. Cell phone Tower (মোবাইল টাওয়ার)

7. How long has that tower been here? (এই টাওয়ারটি এইখানে কতদিন ধরে আছে?)

A. less than 1 year (১ বছরের কম)

B. 1- 3 years (১-৩ বছর)

C. 3-5 years (৩-৫ বছর)

D. More than 5 years (৫ বছরের বেশি)

8. How far is your home/shop/others from that tower? (আপনার বাসা/দোকান থেকে টাওয়ার এর দূরত্ব কত?)

A. Within 1km radius (১ কি.মি. এর কম)

B. 1-3 km radius (১-৩ কি. মি.)

C. 3-5 Km (৩-৫ কি. মি.)

D. More than 5 km radius (৫ কি.মি. এর বেশি)

9. Do you own or work in any of the agricultural properties located around this tower? (আপনার কি টাওয়ার এর আশে পাশে কোনো জমি আছে, যেখানে আপনি বা অন্য কেউ চাষাবাদ করেন?)

A. Yes (হ্যাঁ)

B. No (না)

10. How many times do you pass this tower on an average daily basis? (আপনি কতবার টাওয়ার এর আশে পাশে চলাচল করেন?)

A. Less than 5 (৫ বারের কম)

B. 5-10 (৫-১০ বার)

C. More than 10 (১০ বারের বেশি)

D. Work or live within the area (টাওয়ারের আশে পাশেই বাড়ি/ দোকান/ অন্য কাজ করেন)

11. What is the voltage of the power line of the tower? (টাওয়ারের পাওয়ার লাইনের ভোল্টেজ কত?)

Questions on effects:

12. Do you have any problems regarding the tower's location? (আপনার কি টাওয়ারের অবস্থান সম্পর্কে কোনো সমস্যা আছে?)

A. Yes (হ্যাঁ)

B. No (না)

13. Did the crops you own show any unusual symptoms after the construction of the tower? (সেল টাওয়ার নির্মাণের পরে আপনার ফসলে কি কোন অস্বাভাবিক লক্ষণ দেখা গেছে?)

14.Have you noticed any changes in the number or variety of insects or birds around the tower? (টাওয়ার বসানোর পর এর আশে পাশে পাখি, পোকামাকড় এর সংখ্যার বা বৈচিত্রের কোনো পরিবর্তন লক্ষ্য করেছেন কী?)

A. Yes (হ্যাঁ)

B. No (না)

15. Did your pet/domestic animal face any health issues after the installation of the tower? (টাওয়ার বসানোর পর আপনার পোষা প্রাণীর স্বাস্থ্যের কোনো পরিবর্তন হয়েছে কী?)

A. Yes (হ্যাঁ)

B. No (না)

16. Have you noticed any changes in the population or diversity of wildlife in the area near the tower? (টাওয়ারের কাছাকাছি এলাকার জনসংখ্যা বা বন্যপ্রাণীর বৈচিত্র্যের কোন পরিবর্তন লক্ষ্য করেছেন কি?)

A. Yes (হ্যাঁ)

B. No (না)

Tower Number		
Magnetic Field (mG) (Vertically Front)		

Magnetic Field (mG) (Vertically Back)		
Magnetic Field (mG) (Vertically Right)		
Magnetic Field (mG) (Vertically Left)		
Magnetic Field (mG) (Average)		
Electric Field (V/m) (Vertically Front)		
Electric Field (V/m) (Vertically Back)		
Electric Field (V/m) (Vertically Right)		
Electric Field (V/m) (Vertically Left)		
Electric Field (V/m) (Average)		
RF Strength (µW/m2) (Vertically Front)		
RF Strength (µW/m2) (Vertically Back)		
RF Strength (µW/m2) (Vertically Right)		
RF Strength (µW/m2) (Vertically Left)		
RF Strength (µW/m2) (Average)		

Awareness based questions:

17. How informed do you feel about the potential risks of tower radiation exposure for plants and animals? (টাওয়ার থেকে বিকিরিত রশ্মি উদ্ভিদ এবং প্রানীর জন্য ক্ষতিকর এ সম্পর্কে আপনি কতটুকু জানেন?)

____

18.Are you aware of any scientific studies that have been conducted on the effects of mobile tower radiation on plants and animals? (উদ্ভিদ এবং প্রানীর উপর টাওয়ার বিকিরনের প্রভাব সম্পর্কে কোনো বৈজ্ঞানিক গবেষণা সম্পর্কে আপনি কি অবগত আছেন?)

A. Yes (হ্যাঁ)

B. No (না)

19. On a scale of 1-10, how concerned are you about the potential health risks associated with mobile tower radiations? (টাওয়ার বিকিরনের যে স্বাস্থ্যঝুকি আছে এ সম্পর্কে আপনি কতটুকু সচেতন? ১-১০ এর মাঝে কত নম্বর দিবেন)

____

20. Do you think that there is a need for further research on the potential effects of mobile tower radiation on plants and animals? (উদ্ভিদ এবং প্রানীর উপর টাওয়ার বিকিরনের যে প্রভাব এই বিষয়টি নিয়ে আরও গবেষণা দরকার, এ বিষয়ে আপনার কি মতামত?)

____

21. Do you have any other concerns or comments regarding the effects of mobile tower radiation on plants and animals? (আপনার কি এই বিকিরনের ক্ষতিকর প্রভাব নিয়ে কোনো মতামত আছে?)

____

22. Are there any steps that you think individuals or communities can take to reduce the potential harm of mobile tower radiation on the environment and ecosystem? (এই সমস্যাটি নিয়ে একজন ব্যক্তি বা সম্প্রদায়ের কি কি পদক্ষেপ নেওয়া দরকার বলে আপনি মনে করেন।)

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Data Collection from Sites with Cell Towers and HVTL Towers

The study examined two primary types of cell towers: **greenfield towers**, freestanding structures located in open spaces away from buildings, and **rooftop towers**, installed atop residential or commercial buildings. This distinction allowed for a thorough analysis of how tower placement and design influence electromagnetic field emissions and their proximity to human populations. Data were collected from a diverse range of locations, each containing either cell towers or **high-voltage transmission lines (HVTL)**, spanning both urban and rural settings. **Urban areas**, with their high density of cell towers and concentrated infrastructure, were selected to assess scenarios of more intense electromagnetic exposure, where people are regularly exposed to stronger signals. **Rural locations**, on the other hand, with fewer sources of electromagnetic radiation and a more dispersed population, provided a comparative perspective on lower exposure levels, highlighting potential differences in impact between urban and rural environments. By including **residential areas**, such as homes near cell towers, and **non-residential spaces** like public areas or fields near HVTL, the study aimed to capture a broad spectrum of living conditions and exposure scenarios. This cross-sectional approach ensured that the data represented diverse environmental and social contexts, offering a comprehensive understanding of how electromagnetic fields (EMF) might affect different groups and settings.

Map of Bangladesh and the places covered:

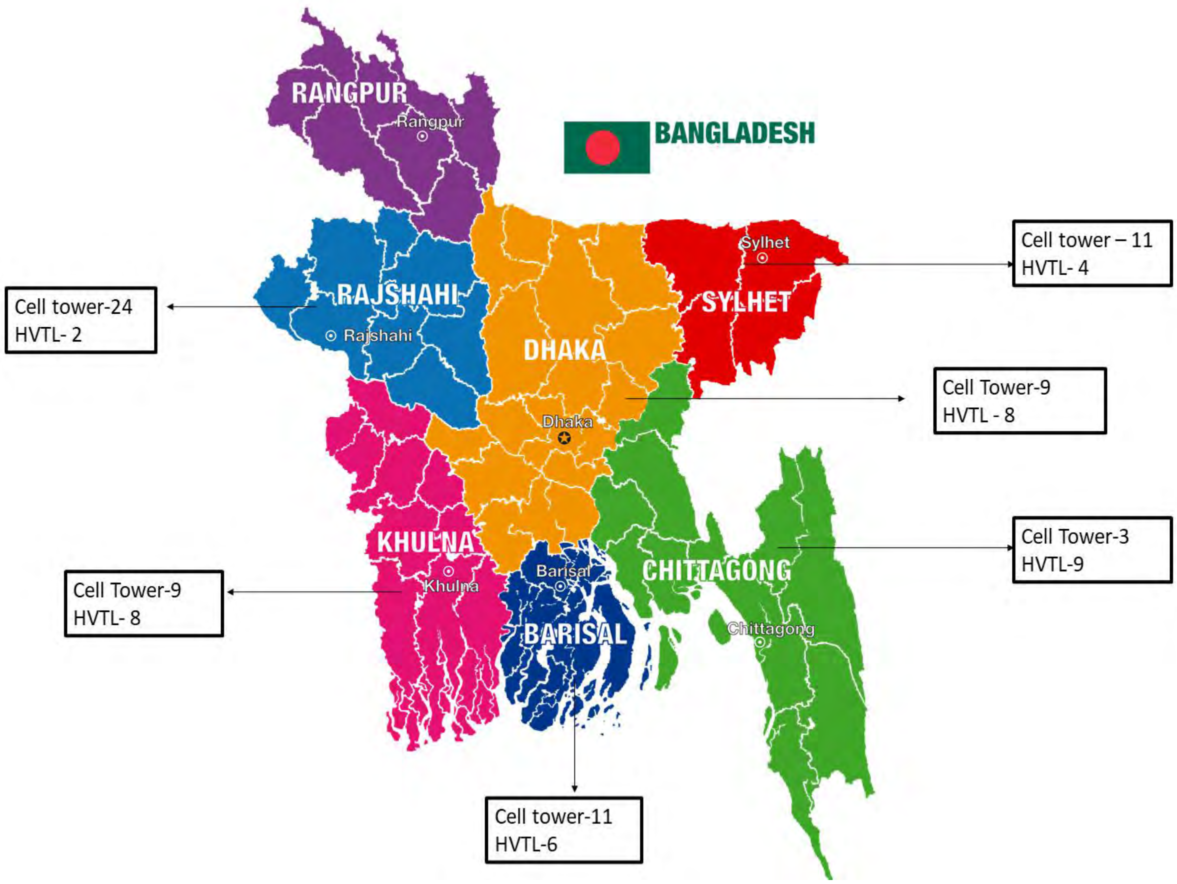
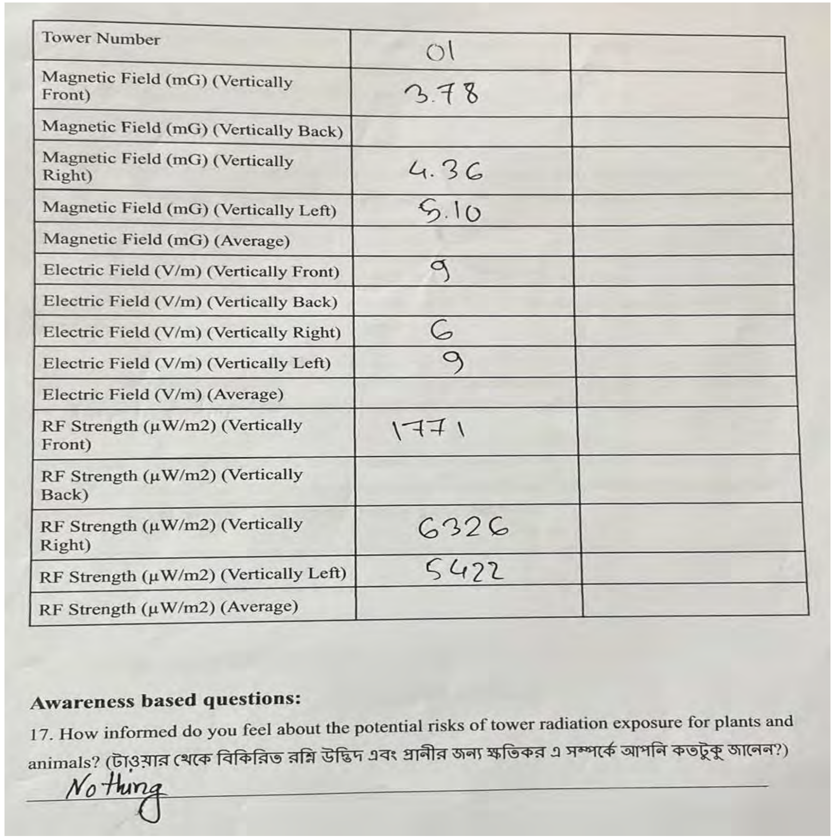


Figure: Map of Bangladesh

The data collected from various divisions in Bangladesh reveals significant variation in the distribution of cell towers and high-voltage transmission lines (HVTLs). We started with Dhaka with both infrastructures being well represented, with 9 cell towers and 8 HVTLs. In Rangpur, we were able to collect data from 7 cell towers and 5 HVTLs. Rajshahi showed a notably higher concentration of telecommunications infrastructure, throughout the city with 24 cell towers compared to only 2 HVTLs that we were able to get our hands on. Next it was Khulna with a more balanced collection of 9 cell towers and 8 HVTL towers. Sylhet also showed a stronger presence of telecommunications infrastructure within the city with 11 cell towers and 4 HVTLs. Chittagong, however, stands out with a higher number of HVTLs (9) compared to only 3 cell towers, indicating a stronger presence of power transmission infrastructure in that division and one of the Potential reasons could be the presence of National Stadium within the heart of the city. These findings highlight the regional variations in infrastructure, which may have different implications for electromagnetic field (EMF) exposure across divisions

Organization of Numerical Data into Tables for Tower Comparison

The numerical data from the EMF measurements were systematically organized into tables, categorizing emissions from different cell towers and HVTL structures. These tables facilitated clear comparisons between the emission levels recorded at various locations, allowing us to analyze whether the recorded values exceeded standard safety thresholds for electric fields, magnetic fields, and radio frequency emissions through graphical analysis. In addition to basic comparisons, regression, and correlation analyses were conducted to explore relationships between different variables, such as emission levels, distance from the towers and proximity to human populations.



Tower Number	01	
Magnetic Field (mG) (Vertically Front)	3.78	
Magnetic Field (mG) (Vertically Back)		
Magnetic Field (mG) (Vertically Right)	4.36	
Magnetic Field (mG) (Vertically Left)	5.10	
Magnetic Field (mG) (Average)		
Electric Field (V/m) (Vertically Front)	9	
Electric Field (V/m) (Vertically Back)		
Electric Field (V/m) (Vertically Right)	6	
Electric Field (V/m) (Vertically Left)	9	
Electric Field (V/m) (Average)		
RF Strength (µW/m2) (Vertically Front)	1771	
RF Strength (µW/m2) (Vertically Back)		
RF Strength (µW/m2) (Vertically Right)	6326	
RF Strength (µW/m2) (Vertically Left)	5422	
RF Strength (µW/m2) (Average)		

Awareness based questions:

17. How informed do you feel about the potential risks of tower radiation exposure for plants and animals? (টাওয়ার থেকে বিকিরিত রশ্মি উদ্ভিদ এবং প্রানীর জন্য ক্ষতিকর এ সম্পর্কে আপনি কতটুকু জানেন?)

Nothing

Figure 12: The numerical data from the EMF measurements

Additionally, these tables were cross-referenced with the health data collected from the questionnaires, allowing us to investigate any potential links between higher exposure levels and adverse health outcomes.

COLLECTED DATA:

Area Name	Tower Type	Tower Placement	Magnetic Field (mG)	Electric Field (V/m)	RF Strength (µW/m^2)
Dhaka 01	**HVTL**	**Openfield**	**2.79**	**9**	**1110.67**
Dhaka 02	**HVTL**	**Openfield**	**2.9**	**99.7**	**991.75**
Dhaka 03	**HVTL**	**Openfield**	**5.45**	**330**	**4544.5**
Dhaka 04	**HVTL**	**Openfield**	**0.455**	**10.5**	**908**

Dhaka 05	**CT**	**Rooftop**	**3.12**	**9.055**	**951.59**
Dhaka 06	**CT**	**Rooftop**	**3.12**	**9.055**	**951.59**
Jamalpur 01	**CT**	**Rooftop**	**0.14**	**6**	**1330**
Jamalpur 02	**CT**	**Rooftop**	**0.14**	**6.75**	**982.2**
Jamalpur 03	**HVTL**	**Openfield**	**0.13**	**8.25**	**302.45**
Jamalpur 04	**HVTL**	**Openfield**	**0.21**	**7.5**	**366.87**
Jamalpur 05	**HVTL**	**Openfield**	**6.5**	**8.915**	**879.1**
Jamalpur 06	**CT**	**Openfield**	**1.74**	**330**	**4544.5**
Jamalpur 07	**CT**	**Rooftop**	**0.55**	**9**	**560**
Savar 01	**CT**	**Rooftop**	**4.42**	**8**	**4506.34**
Savar 02	**CT**	**Rooftop**	**14.94**	**111**	**42.3**
Savar 03	**HVTL**	**Openfield**	**0.55**	**6**	**2.15**
Savar 04	**CT**	**Rooftop**	**1.3**	**6.75**	**58.275**
Chittagong 01	**CT**	**Openfield**	**4.51**	**22.5**	**2090.5**
Chittagong 02	**HVTL**	**Openfield**	**9.45**	**93**	**2366.5**
Chittagong 03	**HVTL**	**Openfield**	**10.825**	**354**	**3953**
Chittagong 04	**HVTL**	**Openfield**	**3.74**	**12**	**29.65**
Chittagong 05	**HVTL**	**Openfield**	**4.27**	**17**	**55.6**
Chittagong 06	**HVTL**	**Openfield**	**11.54**	**9**	**370**
Chittagong 07	**HVTL**	**Openfield**	**3.39**	**11**	**52.7**
Chittagong 08	**HVTL**	**Openfield**	**7.48**	**10.5**	**4074.75**
Chittagong 09	**HVTL**	**Openfield**	**10.28**	**7.67**	**100.62**
Chittagong 10	**CT**	**Openfield**	**0.895**	**6.75**	**429.875**
Chittagong 11	**CT**	**Rooftop**	**2.5**	**10.5**	**60.375**
Chittagong 12	**HVTL**	**Openfield**	**6.84**	**33**	**742**

Magura 01	**CT**	**Rooftop**	**0.81**	**9.75**	**85**
Magura 02	**CT**	**Rooftop**	**2.1**	**22**	**423.34**
Magura 03	**CT**	**Rooftop**	**0.59**	**8.25**	**228.5**
Magura 04	**CT**	**Rooftop**	**8.86**	**16.5**	**236.7**
Rajshahi 01	**CT**	**Rooftop**	**0.19**	**12**	**247.75**
Rajshahi 02	**CT**	**Rooftop**	**0.16**	**6**	**360.1**
Rajshahi 03	**CT**	**Rooftop**	**2.9**	**15**	**159.9**
Rajshahi 04	**CT**	**Rooftop**	**0.13**	**9**	**288**
Rajshahi 05	**CT**	**Rooftop**	**0.35**	**7.5**	**129.5**
Rajshahi 06	**CT**	**Rooftop**	**0.88**	**6**	**765.6**
Rajshahi 07	**CT**	**Openfield**	**0.53**	**9**	**52.7**
Rajshahi 08	**CT**	**Rooftop**	**0.44**	**9**	**223.95**
Rajshahi 09	**CT**	**Openfield**	**0.65**	**18**	**122.2**
Rajshahi 10	**CT**	**Rooftop**	**12.36**	**9**	**323.3**
Rajshahi 11	**CT**	**Openfield**	**1.95**	**9**	**466.5**
Rajshahi 12	**CT**	**Rooftop**	**0.15**	**11**	**859.87**
Rajshahi 13	**CT**	**Rooftop**	**0.27**	**9**	**1037.87**
Rajshahi 14	**CT**	**Openfield**	**1.67**	**10**	**279.7**
Rajshahi 15	**CT**	**Rooftop**	**3.135**	**16.5**	**361**
Rajshahi 16	**HVTL**	**Openfield**	**4.15**	**126**	**103.66**
Rajshahi 17	**CT**	**Rooftop**	**1.49**	**9.1**	**2051.3**
Rajshahi 18	**CT**	**Rooftop**	**5.37**	**16.33**	**0.42**
Rajshahi 19	**CT**	**Rooftop**	**0.15**	**9**	**1645**
Rajshahi 20	**CT**	**Rooftop**	**0.3**	**10.5**	**2040.5**
Rajshahi 21	**CT**	**Rooftop**	**0.47**	**7.5**	**23.8**

Rajshahi 22	**CT**	**Rooftop**	**0.8**	**9**	**39.85**
Rajshahi 23	**CT**	**Rooftop**	**1.14**	**9**	**3009.3**
Rajshahi 24	**CT**	**Rooftop**	**2.84**	**12**	**5422**
Rajshahi 25	**HVTL**	**Openfield**	**4.97**	**22.67**	**633.6**
Rajshahi 26	**CT**	**Rooftop**	**0.6**	**9**	**2163**
Naogaon 01	**CT**	**Rooftop**	**2.81**	**13.5**	**2125.5**
Naogaon 02	**CT**	**Rooftop**	**0.26**	**6.75**	**156.7**
Naogaon 03	**HVTL**	**Openfield**	**10.59**	**24.67**	**2512**
Naogaon 04	**CT**	**Openfield**	**0.25**	**7**	**398.1**
Naogaon 05	**HVTL**	**Openfield**	**0.27**	**12**	**731.7**
Naogaon 06	**HVTL**	**Openfield**	**2.02**	**19.5**	**1329.4**
Naogaon 07	**CT**	**Openfield**	**0.75**	**6**	**567.8**
Naogaon 08	**CT**	**Rooftop**	**0.42**	**10**	**338.4**
Naogaon 09	**HVTL**	**Openfield**	**0.22**	**9**	**496**
Naogaon 10	**CT**	**Rooftop**	**0.39**	**9**	**397.6**
Naogaon 11	**HVTL**	**Openfield**	**3.1**	**10**	**3407.67**
Naogaon 12	**CT**	**Openfield**	**0.63**	**9**	**657.67**
Sylhet 01	**CT**	**Rooftop**	**0.63**	**6**	**347.6**
Sylhet 02	**CT**	**Rooftop**	**0.61**	**15**	**260.7**
Sylhet 03	**CT**	**Rooftop**	**0.54**	**9**	**160.8**
Sylhet 04	**HVTL**	**Openfield**	**10.5**	**96**	**2467**
Sylhet 05	**HVTL**	**Openfield**	**10.825**	**258**	**3954**
Sylhet 06	**HVTL**	**Openfield**	**3.78**	**7**	**27.68**
Sylhet 07	**HVTL**	**Openfield**	**5.76**	**9**	**55.8**
Sylhet 08	**CT**	**Rooftop**	**0.45**	**9**	**224.9**

Sylhet 09	**CT**	**Openfield**	**0.96**	**15**	**125.6**
Sylhet 10	**CT**	**Rooftop**	**15.36**	**6**	**326.8**
Sylhet 11	**CT**	**Openfield**	**3.95**	**9**	**477.6**
Sylhet 12	**CT**	**Rooftop**	**0.45**	**12**	**856.3**
Sylhet 13	**CT**	**Rooftop**	**0.67**	**9**	**1085.47**
Sylheti 14	**CT**	**Openfield**	**1.97**	**10.5**	**280.5**
Sylhet 15	**CT**	**Rooftop**	**4.125**	**15.5**	**365**
Barishal 01	**CT**	**Rooftop**	**2.97**	**13**	**2365**
Barishal 02	**HVTL**	**Openfield**	**12.6**	**9**	**480**
Barishal 03	**HVTL**	**Openfield**	**3.45**	**12**	**55.6**
Barishal 04	**HVTL**	**Openfield**	**9.8**	**11**	**4075.6**
Barishal 05	**HVTL**	**Openfield**	**8.6**	**9**	**102.3**
Barishal 06	**HVTL**	**Openfield**	**2.2**	**21.5**	**1259**
Barishal 07	**CT**	**Openfield**	**0.78**	**7**	**589**
Barishal 08	**CT**	**Rooftop**	**1.42**	**10**	**338.9**
Barishal 09	**HVTL**	**Openfield**	**2.33**	**9**	**495**
Barishal 10	**CT**	**Rooftop**	**3.45**	**12**	**87**
Barishal 11	**CT**	**Rooftop**	**3.4**	**24**	**782**
Barishal 12	**CT**	**Rooftop**	**0.58**	**9**	**356**
Barishal 13	**CT**	**Rooftop**	**7.56**	**12.5**	**436.7**
Khulna 01	**HVTL**	**Openfield**	**3.78**	**12**	**1225**
Khulna 02	**HVTL**	**Openfield**	**0.05**	**10.8**	**990**
Khulna 03	**HVTL**	**Openfield**	**5.65**	**236**	**4650**
Khulna 04	**HVTL**	**Openfield**	**0.755**	**10.5**	**908**
Khulna 05	**CT**	**Rooftop**	**4.25**	**10.55**	**986.3**

Khulna 06	**CT**	**Rooftop**	**2.25**	**9.5**	**997.6**
Khulna 07	**HVTL**	**Openfield**	**3.63**	**15**	**63.2**
Khulna 08	**HVTL**	**Openfield**	**7.89**	**12**	**4257.8**
Khulna 09	**HVTL**	**Openfield**	**11.56**	**8.9**	**125.36**
Khulna 10	**CT**	**Openfield**	**0.75**	**7.55**	**429.8**
Khulna 11	**CT**	**Rooftop**	**2.6**	**10.5**	**60**
Khulna 12	**HVTL**	**Openfield**	**5.65**	**35**	**892.6**
Khulna 13	**CT**	**Rooftop**	**0.37**	**7.4**	**153.6**
Khulna 14	**CT**	**Rooftop**	**2.3**	**9**	**785.6**
Khulna 15	**CT**	**Openfield**	**1.56**	**6**	**48.9**
Khulna 16	**CT**	**Rooftop**	**0.45**	**8**	**233.6**
Khulna 17	**CT**	**Openfield**	**0.98**	**21**	**226.3**

Chapter 08

Result

The results section presents the findings of the study, focusing on the electromagnetic field (EMF) emissions from cell towers and high-voltage transmission lines (HVTL) across various locations. The data are analyzed in relation to established safety standards for electric fields, magnetic fields, and radio frequency (RF) emissions. The results are presented in both statistical and graphical formats, providing a comprehensive view of the findings.

Statistical Analysis:

General Interpretation of Correlation Values:

- -1 = Negative correlation.
- -0.9 to -1 = Very High Negative correlation.
- -0.7 to -0.9 = High Negative correlation.
- -0.5 to -0.7 = Moderate Negative correlation.
- -0.3 to -0.5 = Low Negative correlation.
- 0 to -0.3 = No correlation.
- 0 to 0.3 = No correlation.
- 0.3 to 0.5 = Low Positive correlation.
- 0.5 to 0.7 = Moderate Positive correlation.
- 0.7 to 0.9 = High Positive correlation.
- 0.9 to 1 = Very High Positive correlation.
- 1 = Positive correlation.

Correlation between Magnetic Field and Electric Field (0.303): It is a Low Positive correlation, meaning that as the Magnetic Field increases, the Electric Field tends to increase. However, the value is Low which is indicating that while there is some relationship, it’s not very strong.

Correlations			
		Magnetic Field (mG)	Electric Field (V/m)
Magnetic Field (mG)	Pearson Correlation	1	.303**
	Sig. (2-tailed)		.001
	N	116	116
Electric Field (V/m)	Pearson Correlation	.303**	1
	Sig. (2-tailed)	.001	
	N	116	116

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between Magnetic Field and RF Strength (0.243): This correlation is negligible correlation. The value is very near to 0.

Correlations			
		Magnetic Field (mG)	RF Strength (µW/m^2)
Magnetic Field (mG)	Pearson Correlation	1	.243**
	Sig. (2-tailed)		.009
	N	116	116
RF Strength (µW/m^2)	Pearson Correlation	.243**	1
	Sig. (2-tailed)	.009	
	N	116	116

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation between Electric Field and RF Strength (0.546): This is a moderate positive correlation. It means that as the Electric Field increases, the RF Strength tends to increase as well. This relationship is stronger than the others, suggesting that the Electric Field and RF Strength are more closely related.

Correlations

		Electric Field (V/m)	RF Strength (μW/m^2)
Electric Field (V/m)	Pearson Correlation	1	.546**
	Sig. (2-tailed)		.000
	N	116	Double-click to activate
RF Strength (μW/m^2)	Pearson Correlation	.546**	1
	Sig. (2-tailed)	.000	
	N	116	116

**. Correlation is significant at the 0.01 level (2-tailed).

Based on our correlation analysis, we can conclude that the three EMF fields are interrelated. This means that if one field increases, the other two are likely to increase as well. Given that there are established optimal exposure ranges for these fields, this correlation suggests that organisms in these areas may be exposed to higher levels of multiple forms of non-ionizing radiation simultaneously, potentially leading to cumulative effects.

Hypothesis Testing: One sample T-test:

In this study, a one-sample t-test was employed to compare the observed mean values of electromagnetic emissions with the established safety thresholds. The significance of the two-tailed test yielded a p-value of less than 0.05, indicating a statistically significant result.

Hypotheses:

- **Null Hypothesis (H_0)**: The emissions do not significantly exceed the prescribed safety limits.
- **Alternative Hypothesis (H_1)**: The emissions significantly surpass the safety limits.

Magnetic Field: The sample data revealed a mean magnetic field strength of **3.28 milligauss (mG)**, which is substantially higher than the safety limit of **0.1 mG**. This clear discrepancy between the observed mean and the threshold strongly suggests that the magnetic field emissions exceed safe exposure levels.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	116	3.28004	3.647888	.338698

One-Sample Test

	Test Value = 0.1					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	9.389	115	.000	3.180043	2.50915	3.85094

Electric Field: Similarly, the mean electric field recorded was **27.81 volts per meter (V/m)**, far surpassing the recommended safety limit of **5 V/m**. This indicates that the electric field consistently and significantly exceeds the safety threshold, pointing to potentially hazardous exposure levels.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	116	27.81134	62.414459	5.795037

One-Sample Test

	Test Value = 5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	3.936	115	.000	22.811336	11.33248	34.29019

RF Strength: The mean radio frequency (RF) strength was found to be **980.45 microwatts per square meter (µW/m²)**, which vastly exceeds the safety guideline of **45 µW/m²**. This substantial difference underscores the alarming levels of RF radiation, far beyond what is considered safe for human exposure.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
RF Strength (µW/m^2)	116	980.44668	1263.036050	117.269953

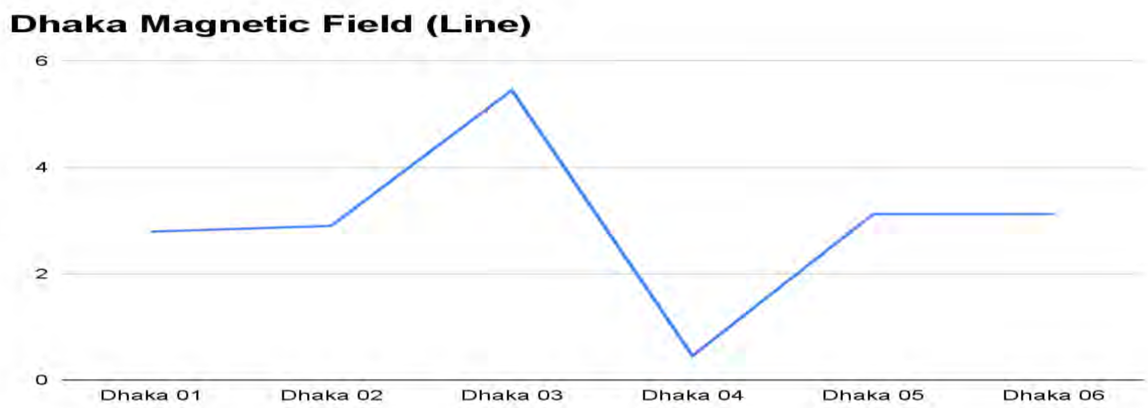
One-Sample Test

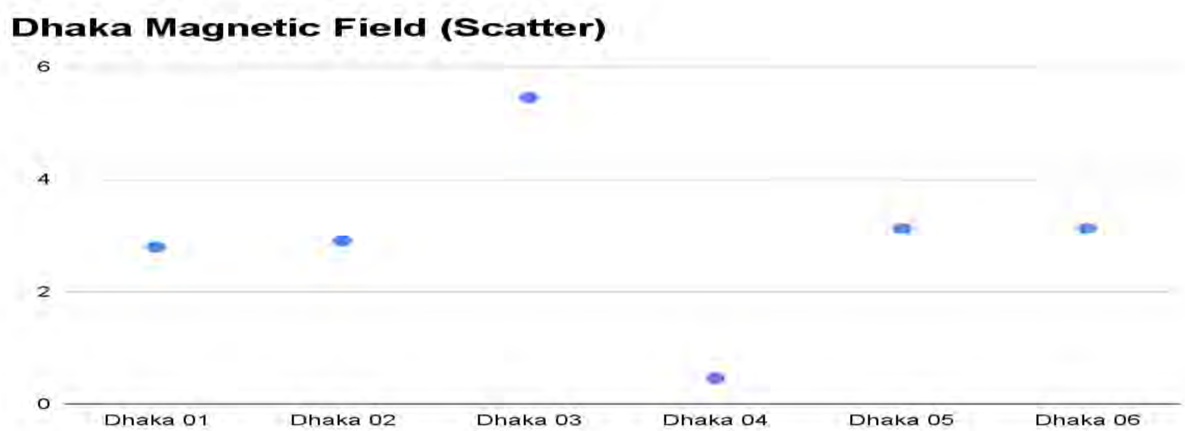
	Test Value = 45					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
RF Strength (µW/m^2)	7.977	115	.000	935.446681	703.15747	1167.73589

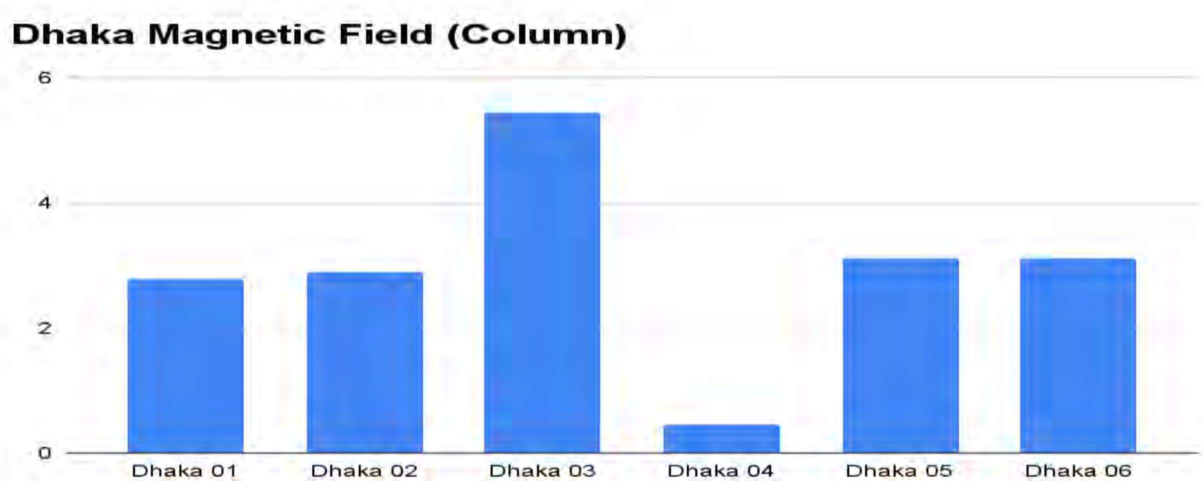
Given these findings, the null hypothesis is **rejected** in favor of the alternative hypothesis, as the emissions—whether from magnetic fields, electric fields, or RF strength—are significantly higher than the safety limits (p-value < 0.05). These results confirm that the measured electromagnetic emissions pose a considerable risk by exceeding the established safety thresholds.

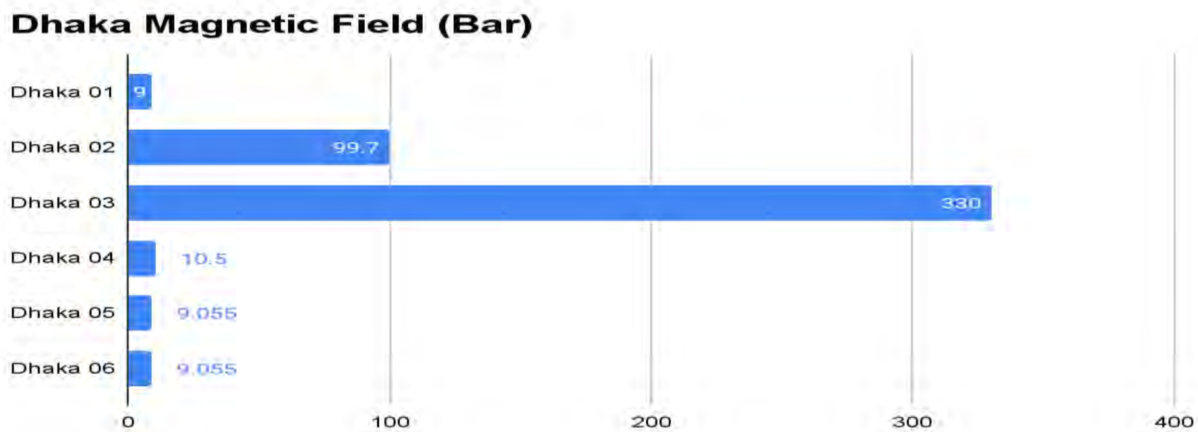
Graphical Analysis:

Here is our graphical analysis of the data that we collected for our research project. We did 4 types of graphs which are Line Plots, Scatter plot, Column Chart, and Bar Charts.

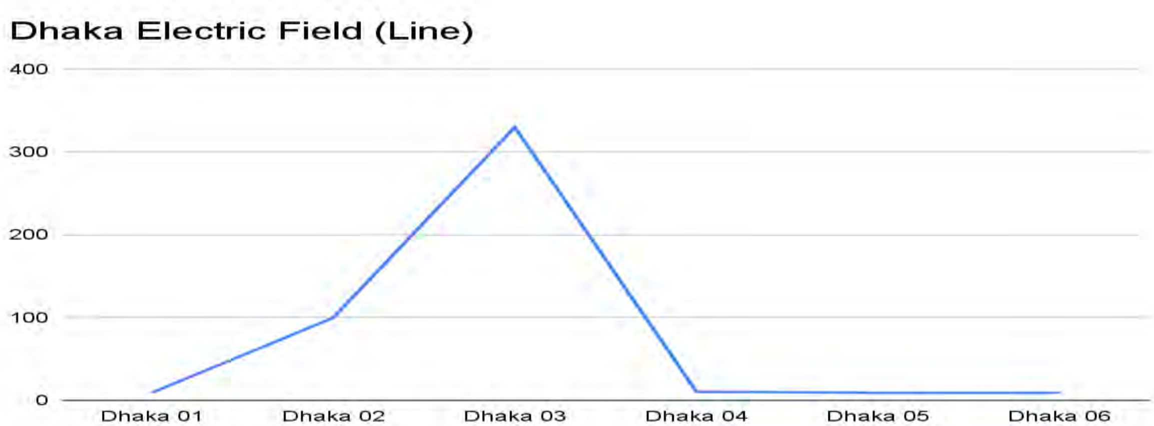


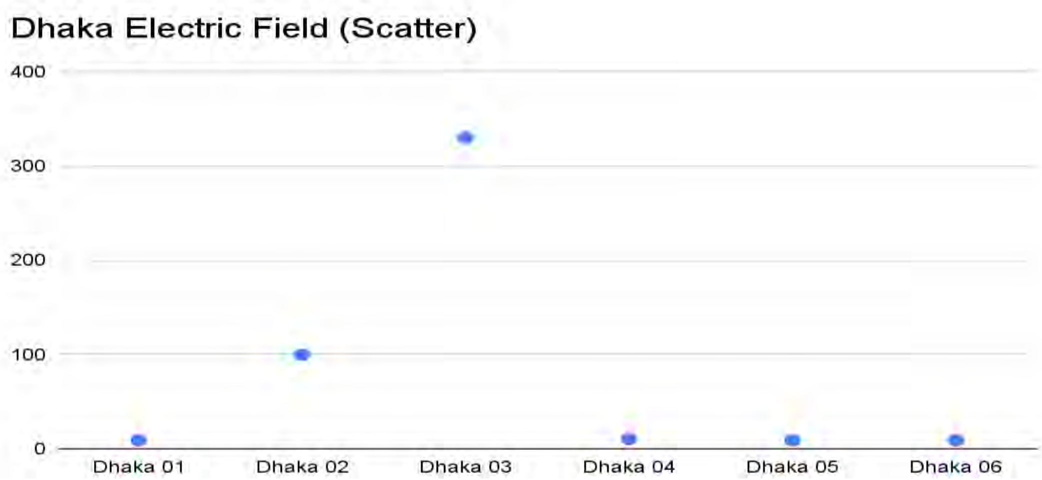


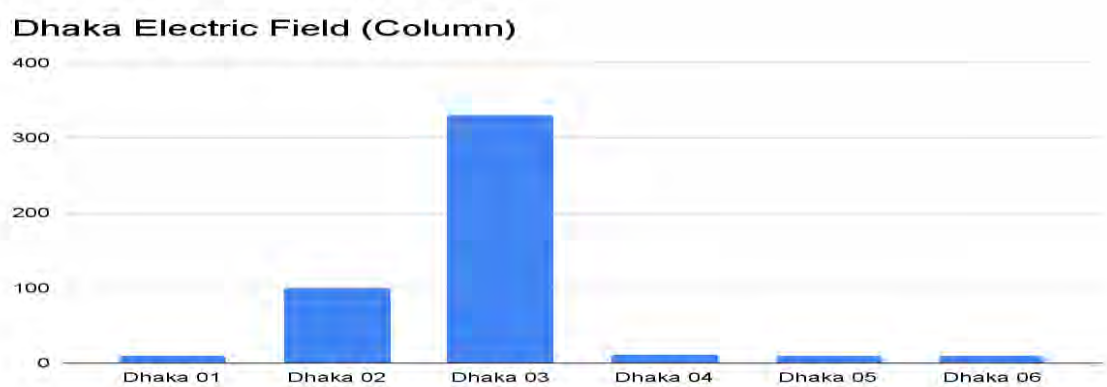


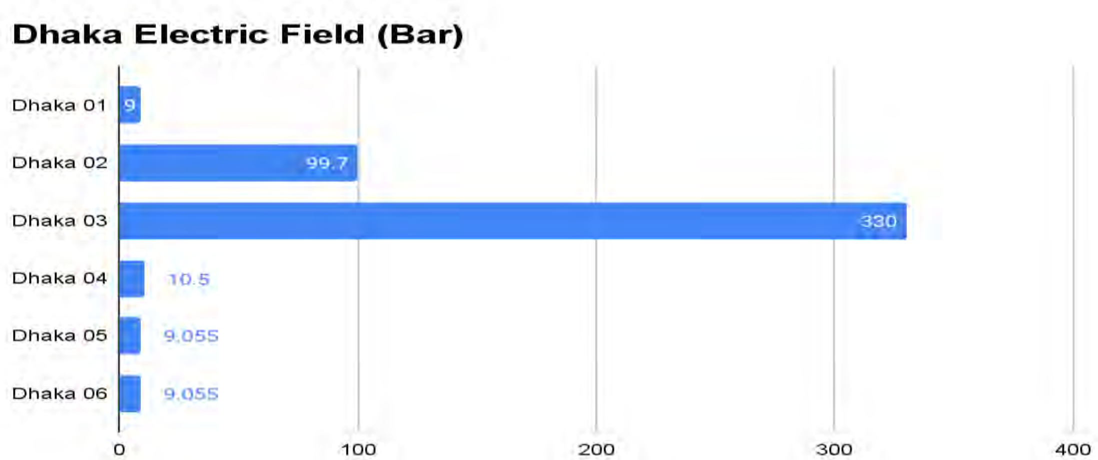


The magnetic field intensity data from cell towers and HVTL towers in Dhaka has been analyzed through a series of bar, line, column, and scatter graphs. The data were collected from 3 cell towers and 3 HVTL towers. From the 3 cell towers, none were found below the threshold value of 0.1 milligauss (mG). For HVTL we found all of them under the range of 1 milligauss (mG) to 200 milligauss (mG). The highest magnetic emission was found to be 330 mG.

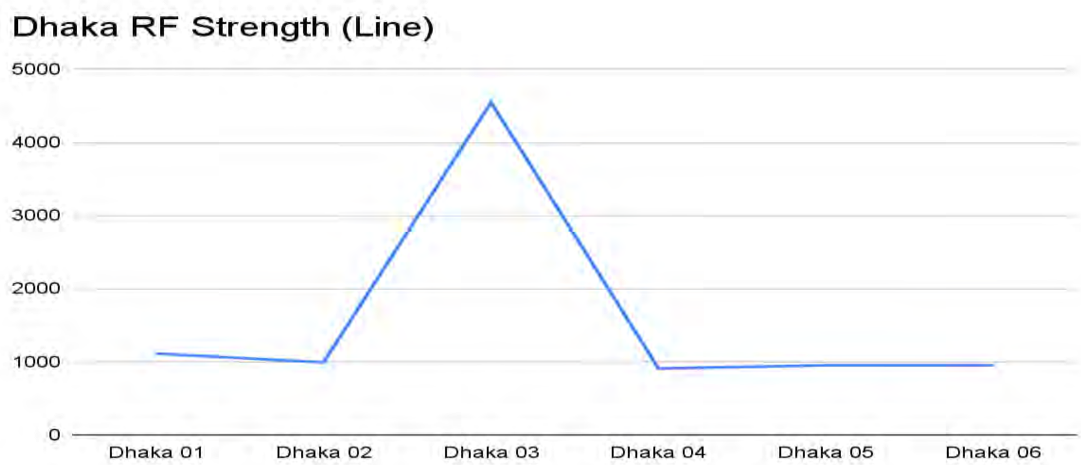


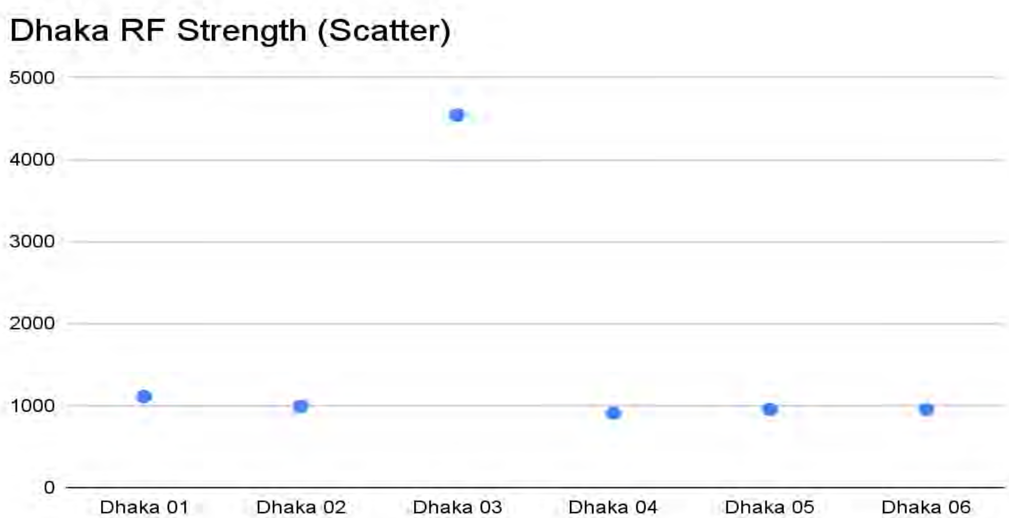


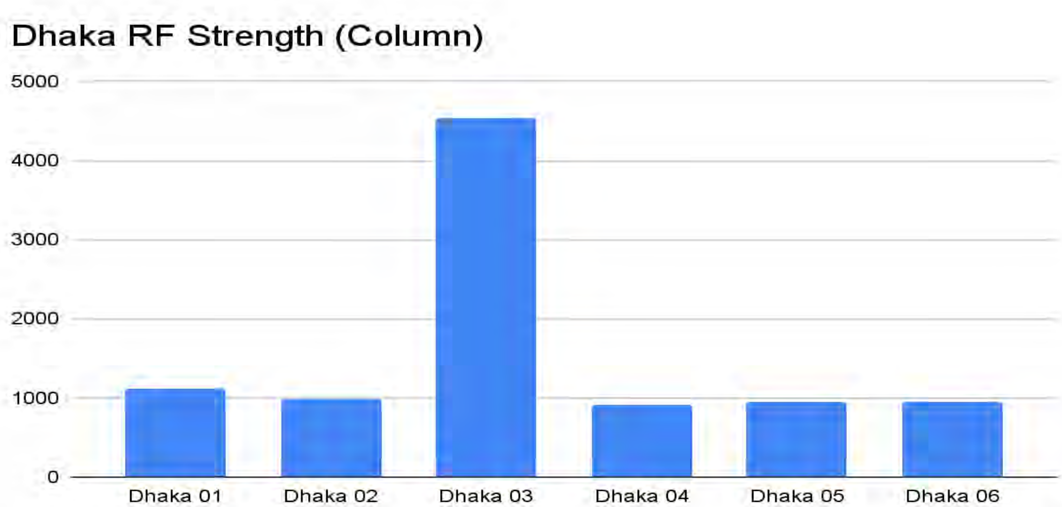


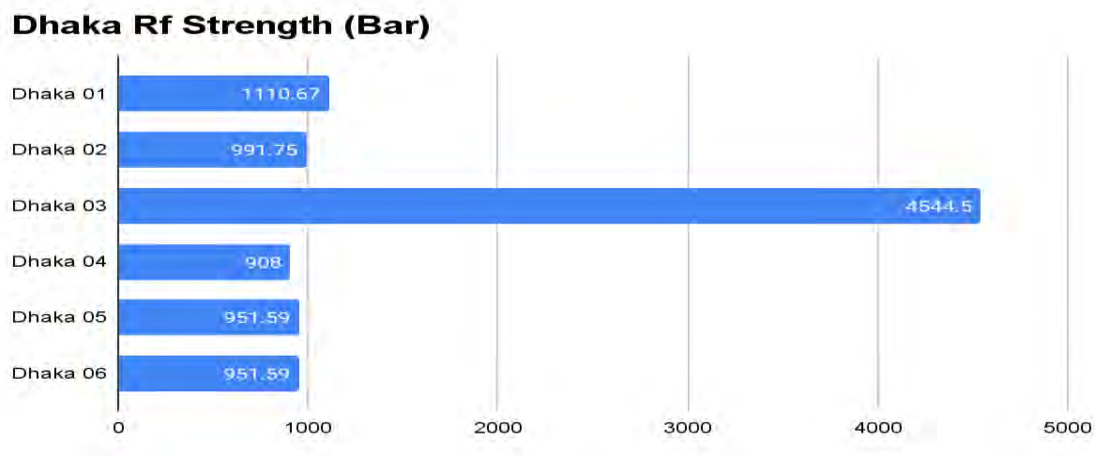


The electric field data for cell towers and HVTL towers in Dhaka is analyzed using a combination of graphs to facilitate comparison and identify trends. All of the cell towers were seen to cross the safety range of 0.5 V/m to 5 V/m, the highest one being 99.7 V/m. For HVTL all of the towers were all under range of 1 kV/m to 10 kV/m

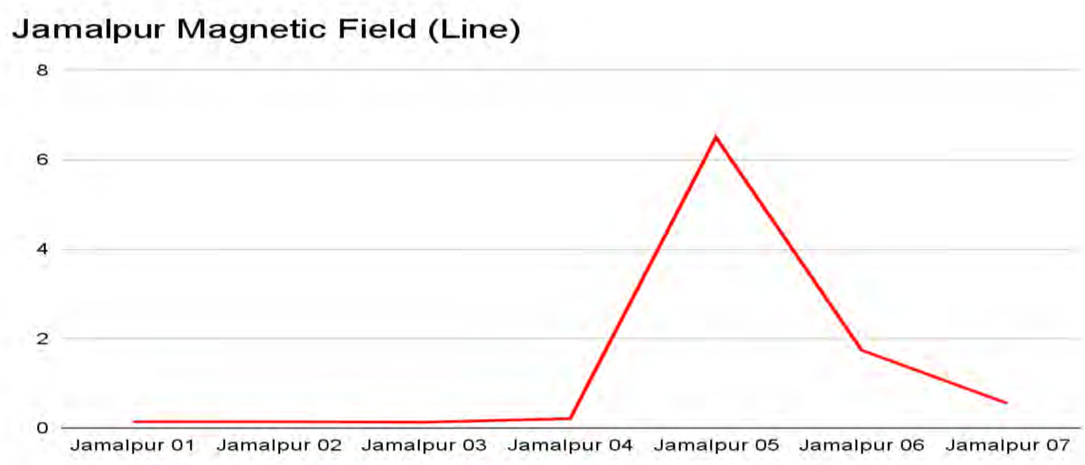

Dhaka RF Strength (Line)
5000
4000
3000
2000
1000
0
Dhaka 01
Dhaka 02
Dhaka 03
Dhaka 04
Dhaka 05
Dhaka 06

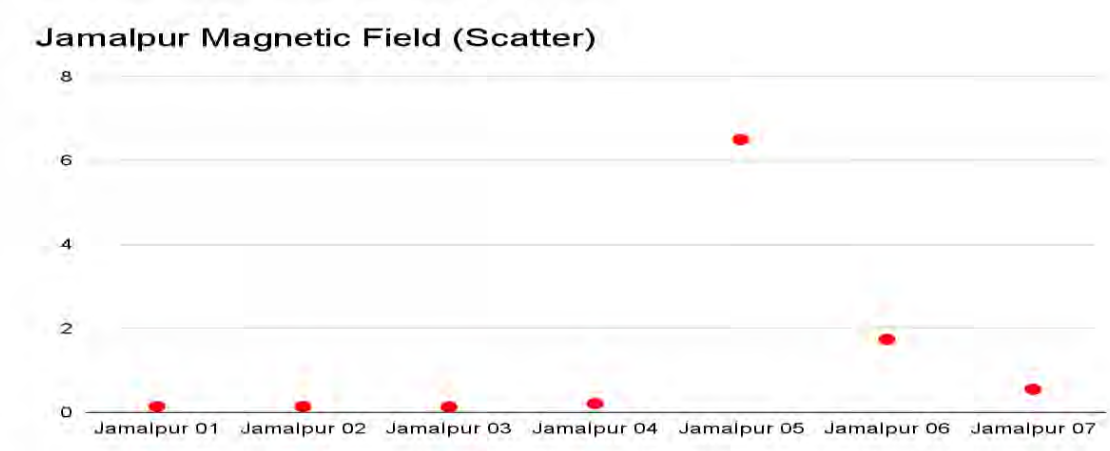

Dhaka RF Strength (Scatter)
5000
4000
3000
2000
1000
0
Dhaka 01
Dhaka 02
Dhaka 03
Dhaka 04
Dhaka 05
Dhaka 06

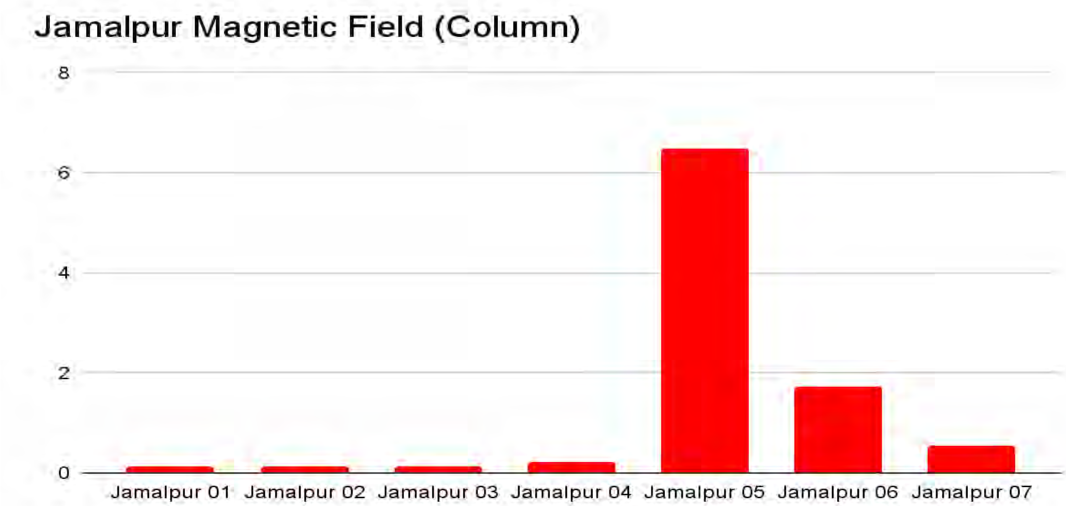

Dhaka RF Strength (Column)
5000
4000
3000
2000
1000
0
Dhaka 01
Dhaka 02
Dhaka 03
Dhaka 04
Dhaka 05
Dhaka 06

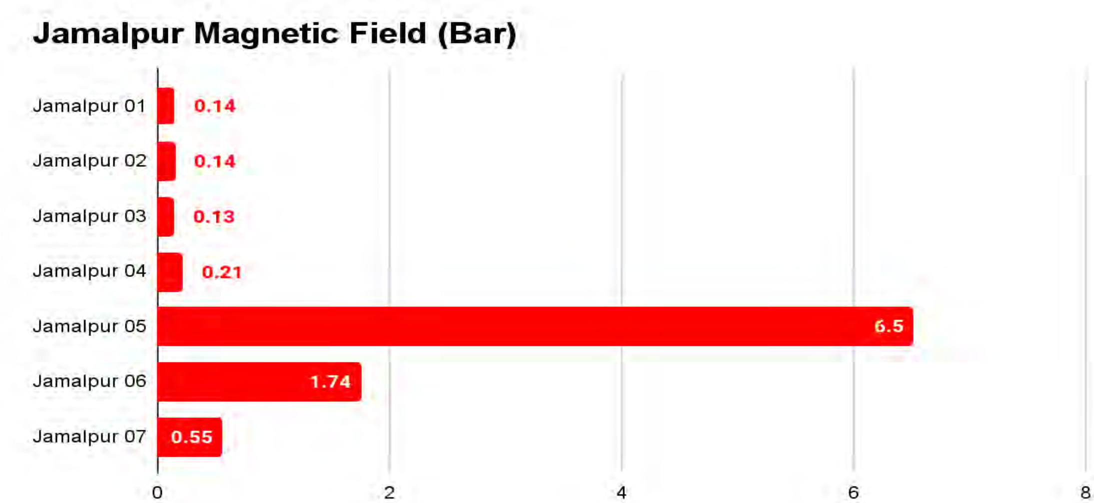


The radio frequency (RF) emissions from both cell towers and HVTL towers were compared using bar, line, column, and scatter graphs. These visualizations make it easy to identify differences, track changes over time, and assess compliance with safety standards. None of the cell towers. All of the cell towers were found to cross the safety threshold which is below 45 µW/m^2. The highest emission was seen to be 4544.5 µW/m^2.

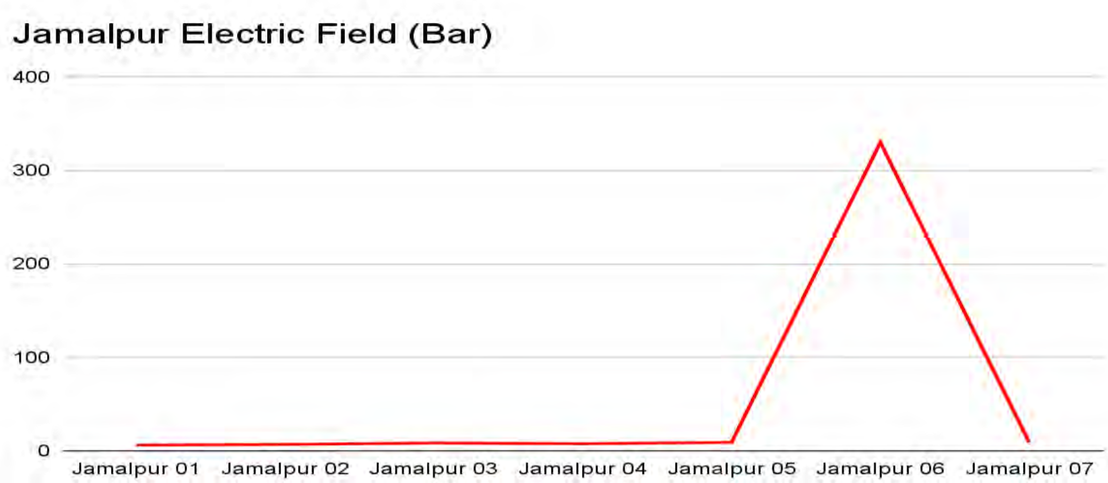


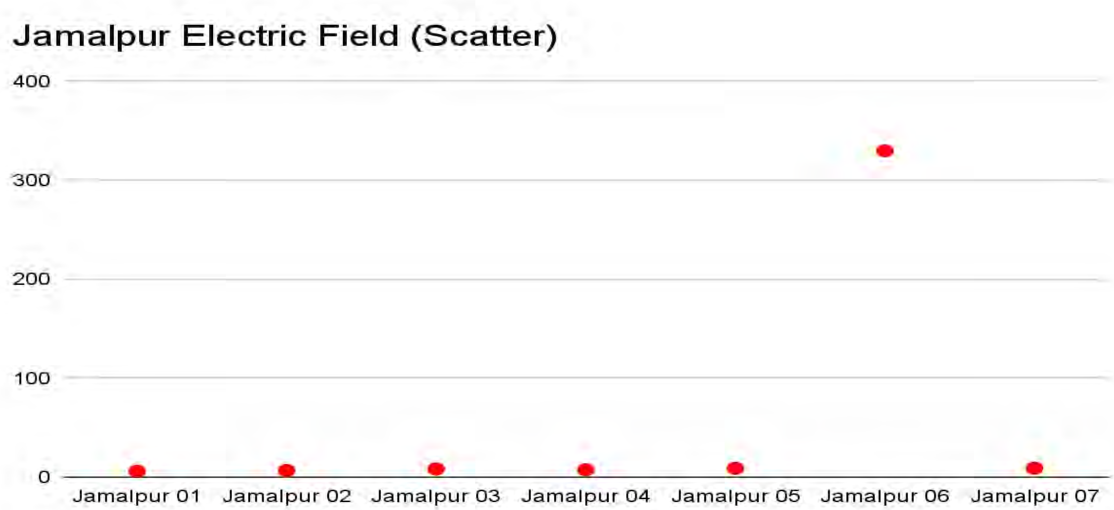


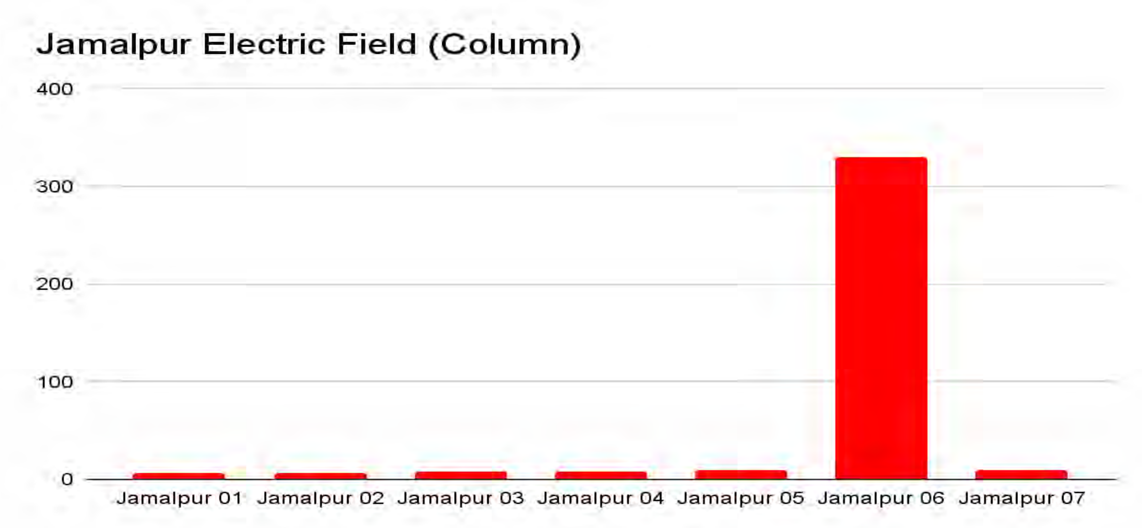


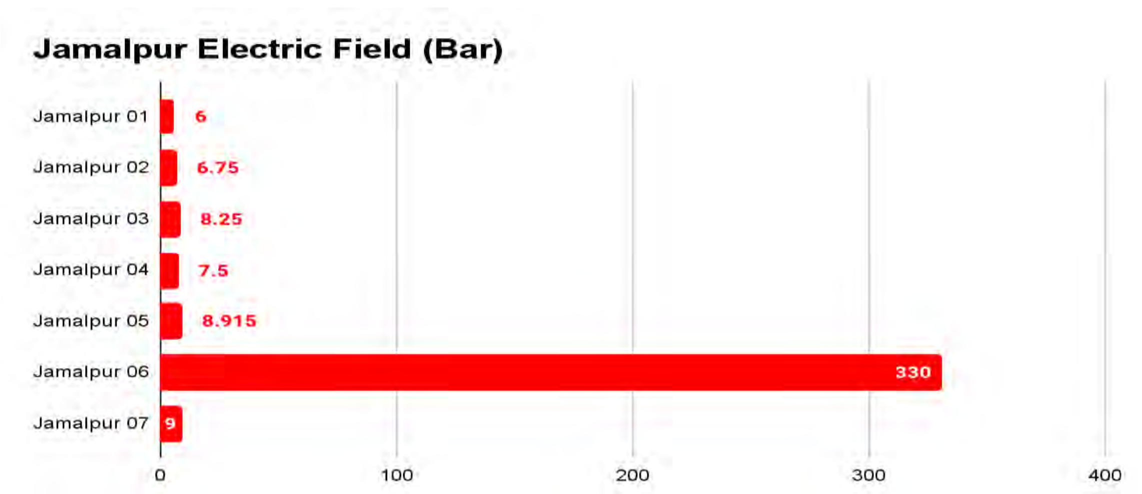


Magnetic field intensities from both cell towers and HVTL towers in Jamalpur are visualized using a series of bar, line, column, and scatter graphs. The **bar graph** effectively highlights the differences between the two tower types, clearly showing that HVTL towers emitted significantly higher magnetic field levels. The **line graph** provides a timeline of how these field strengths fluctuated over time, offering insight into any variations. Meanwhile, the **column graph** compares the average magnetic field values for both tower types against standard threshold limits, providing an easy way to assess whether emissions fall within safe ranges. Although magnetic field emissions from all cell towers slightly exceeded the optimal threshold of 0.1 milligauss (mG), they still performed better than those in neighboring districts. As expected, HVTL towers emitted magnetic fields within the typical range of 1 to 200 mG, adhering to safety standards.

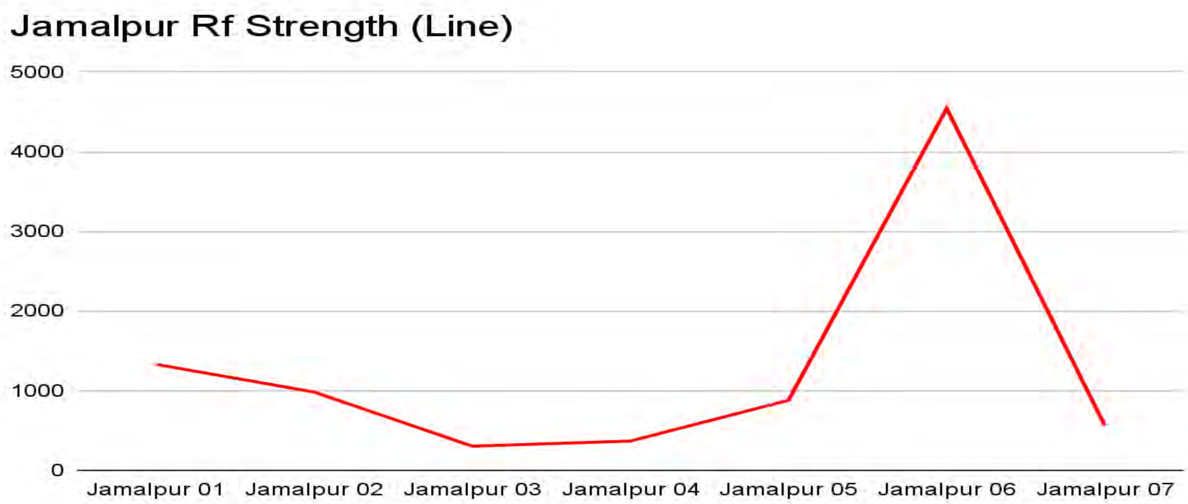


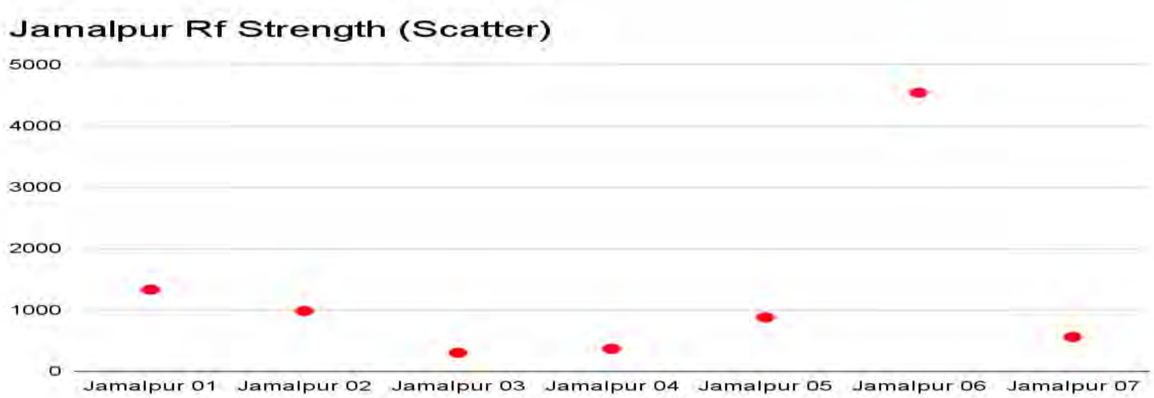


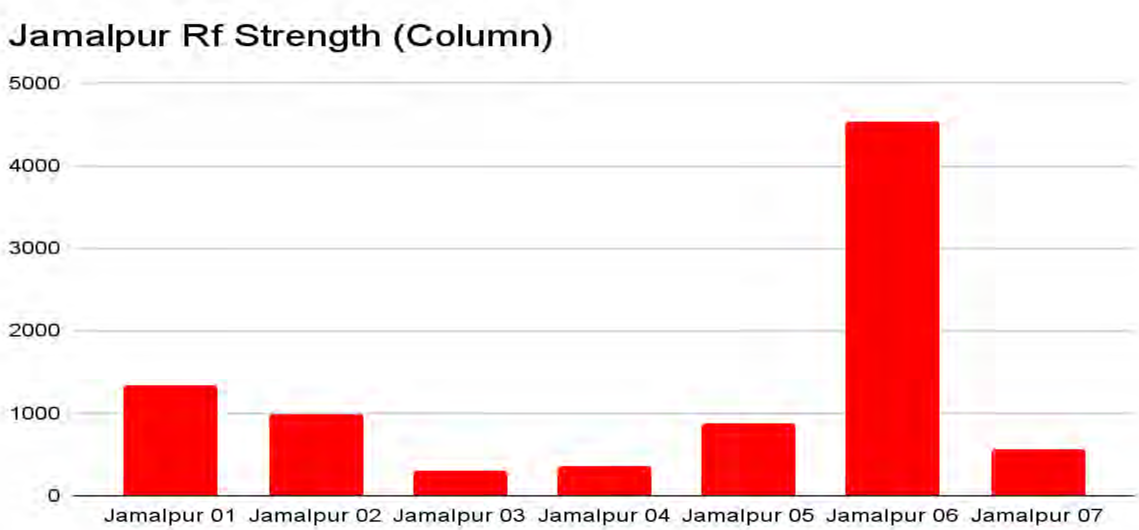




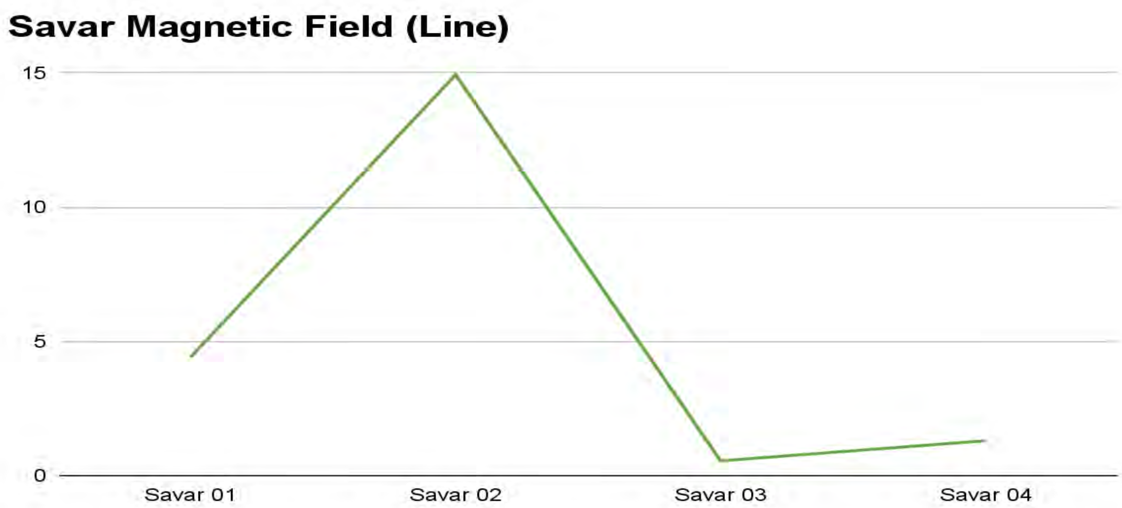
The electric field data from both cell towers and HVTL towers in Jamalpur is presented using multiple graphs to facilitate comparison and trend analysis. The **bar graph** provides a side-by-side comparison of electric field levels between the two tower types, highlighting that while the emissions from the cell towers were relatively close to the optimal range of 0.5 V/m to 5 V/m, they still slightly exceeded it, with values ranging from 6 V/m to 8.91 V/m. In contrast, the HVTL towers showed significantly higher emissions, falling within the expected range of 1 kV/m to 10 kV/m. The **line graph** tracks how electric field intensities varied over time, offering insight into any temporal fluctuations. The **column graph** compares these average electric field values with established safety limits, making it clear which towers are crossing thresholds.

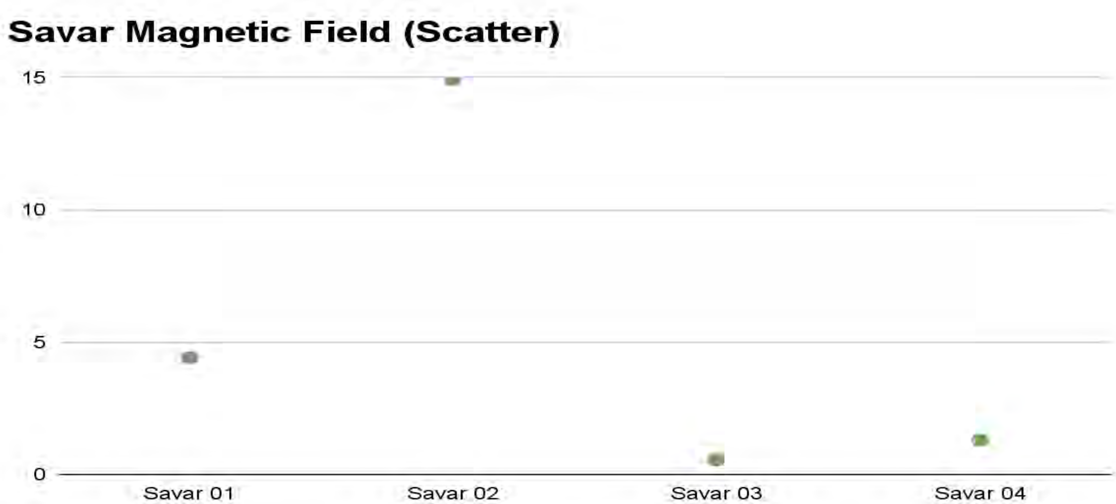

Jamalpur Rf Strength (Line)
5000
4000
3000
2000
1000
0
Jamalpur 01
Jamalpur 02
Jamalpur 03
Jamalpur 04
Jamalpur 05
Jamalpur 06
Jamalpur 07

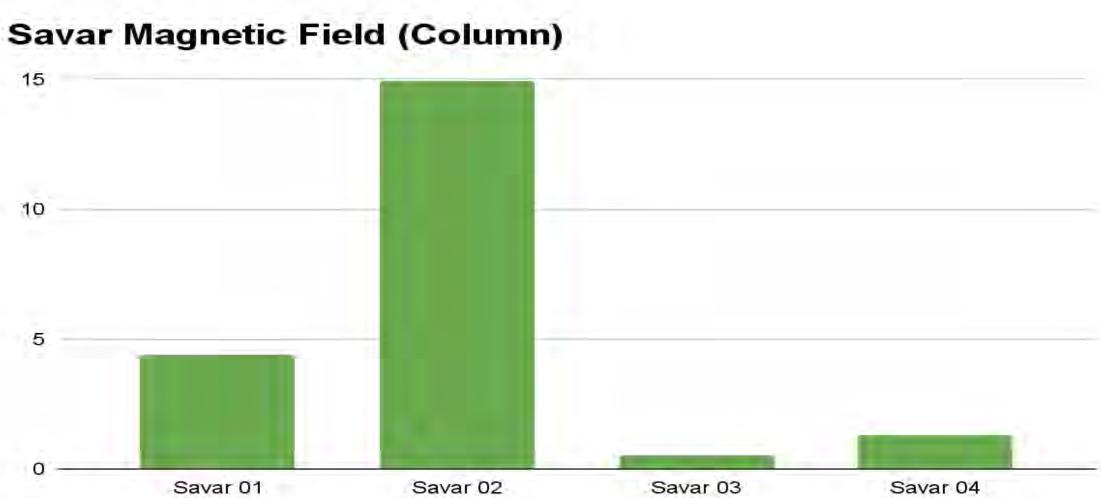

Jamalpur Rf Strength (Scatter)
5000
4000
3000
2000
1000
0
Jamalpur 01
Jamalpur 02
Jamalpur 03
Jamalpur 04
Jamalpur 05
Jamalpur 06
Jamalpur 07

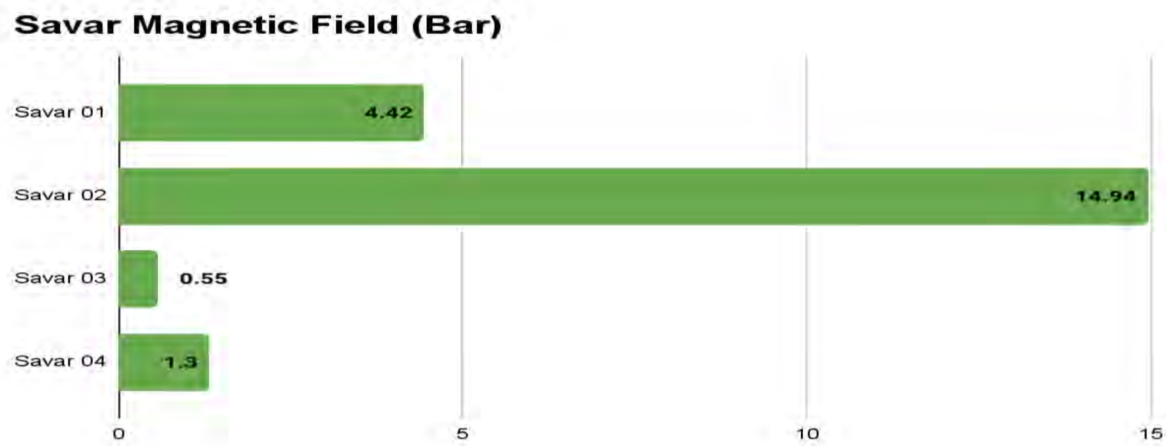

Jamalpur Rf Strength (Column)
5000
4000
3000
2000
1000
0
Jamalpur 01
Jamalpur 02
Jamalpur 03
Jamalpur 04
Jamalpur 05
Jamalpur 06
Jamalpur 07

The radio frequency (RF) emissions from both cell towers and HVTL towers in Jamalpur were compared and visualized through four different graphs. The **bar graph** shows the RF strength for both tower types, allowing for a clear comparison of emissions. Notably, all four cell towers exceeded the optimal safety range of 45 $\mu W/m^2$, with the highest RF strength recorded at 1330 $\mu W/m^2$. Similarly, the HVTL towers also exhibited high emissions, with the maximum RF value reaching 4544.5 $\mu W/m^2$. The **line graph** tracks changes in RF exposure over time, highlighting any significant patterns or spikes in emissions. In the **column graph**, the average RF values are contrasted with the established safety limits, quickly revealing that both cell towers and HVTL towers in Jamalpur far surpass acceptable thresholds. This is further analyzed in the **scatter graph**, where the relationship between RF strength and tower type/location is visualized, emphasizing the extent to which these towers exceed the recommended exposure levels, potentially posing health risks.

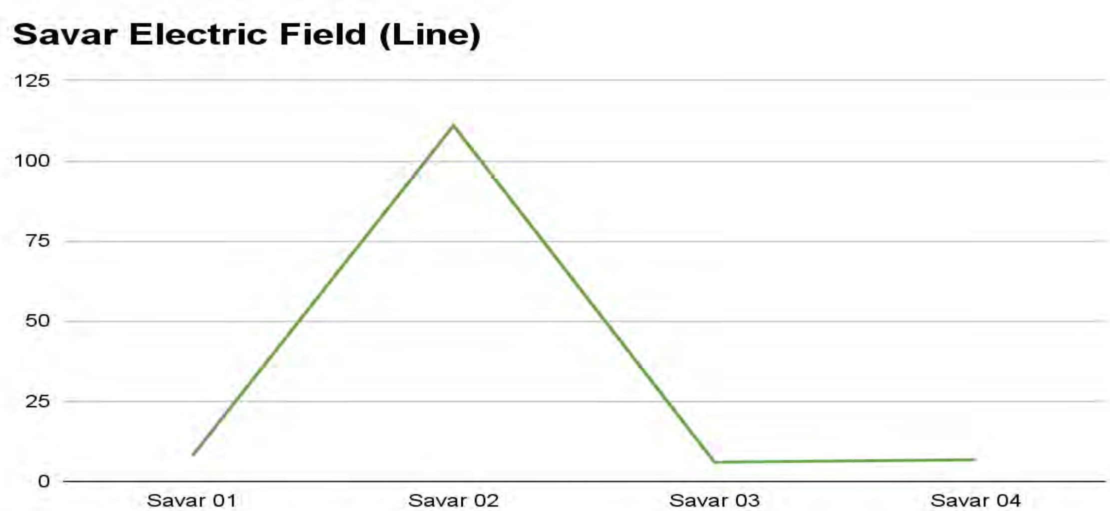

Savar Magnetic Field (Line)
15
10
5
0
Savar 01
Savar 02
Savar 03
Savar 04

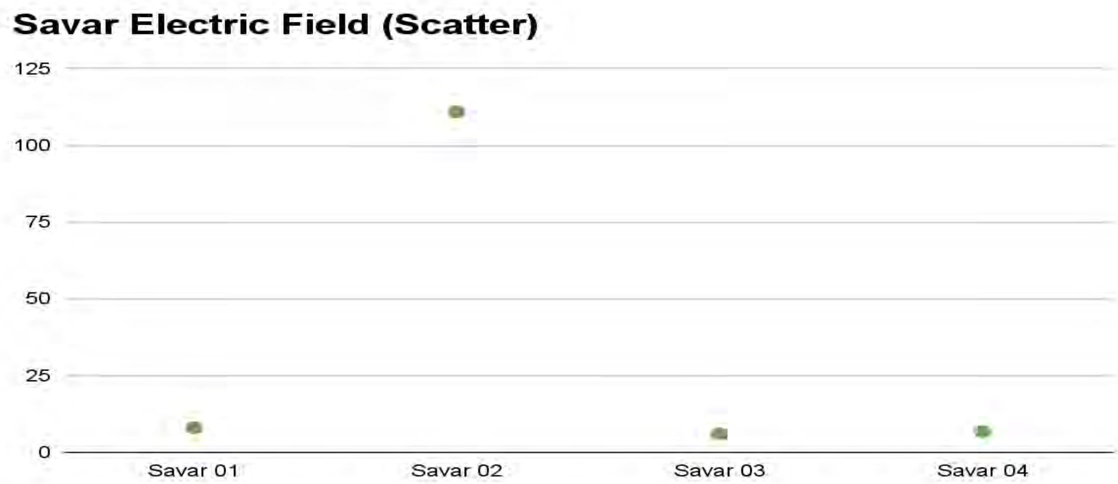

Savar Magnetic Field (Scatter)
15
10
5
0
Savar 01
Savar 02
Savar 03
Savar 04

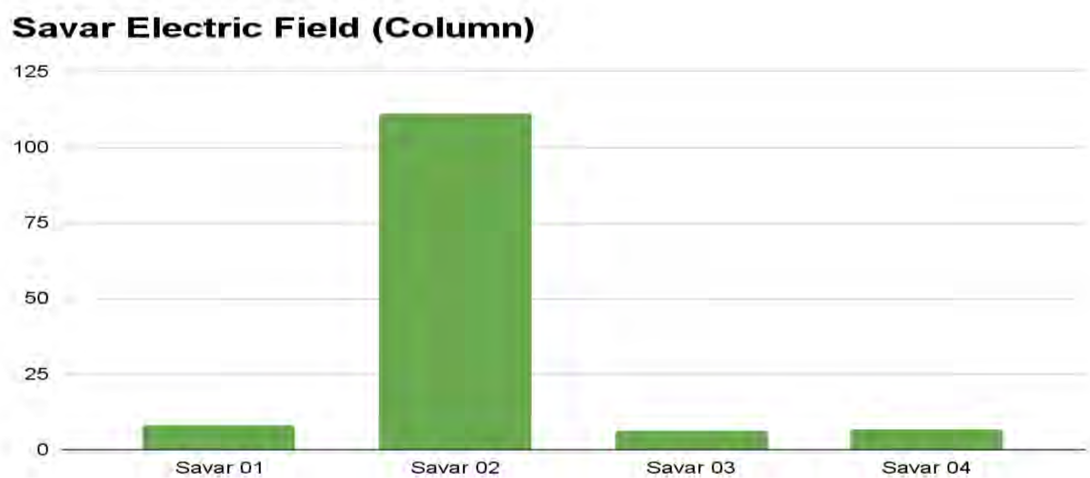

Savar Magnetic Field (Column)
15
10
5
0
Savar 01
Savar 02
Savar 03
Savar 04

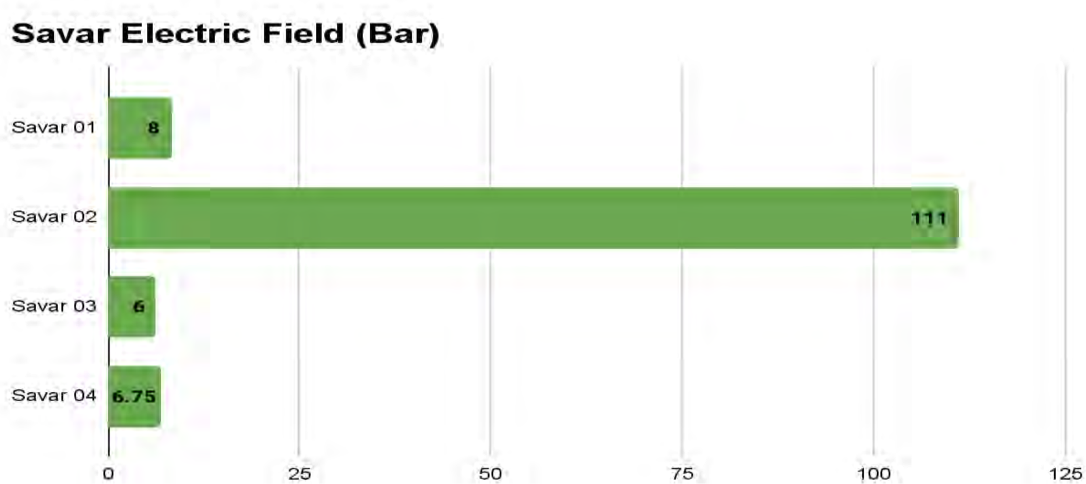


The magnetic field intensity data from cell towers and HVTL towers in Savar has been analyzed through a series of bar, line, column, and scatter graphs. The **bar graph** provides a clear distinction between the emissions from cell towers and HVTL towers, emphasizing which type produces higher magnetic field levels. The **line graph** tracks the fluctuations in magnetic field strength over time, helping to observe any temporal patterns. Using the **column graph**, we compare the average magnetic field values against standard safety limits, offering a straightforward way to evaluate compliance. Lastly, the **scatter graph** explores potential correlations between magnetic field intensities across different locations. Notably, both cell towers exceeded the optimal range of 0.1 milligauss (mG), while HVTL towers performed within acceptable limits, with values of 4.42 and 14.92 mG, comfortably falling within the standard range of 1 to 200 mG.

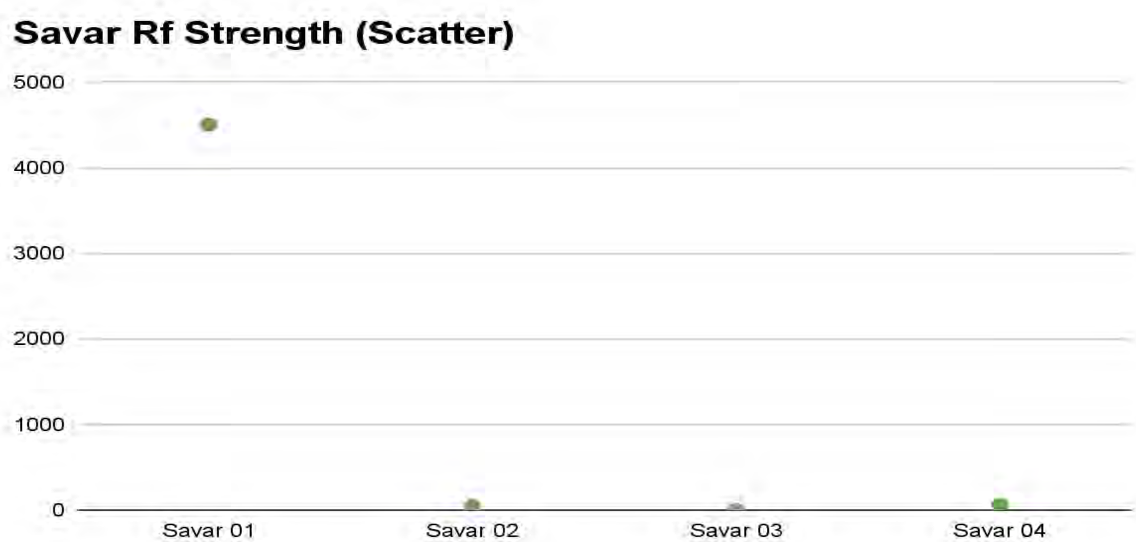


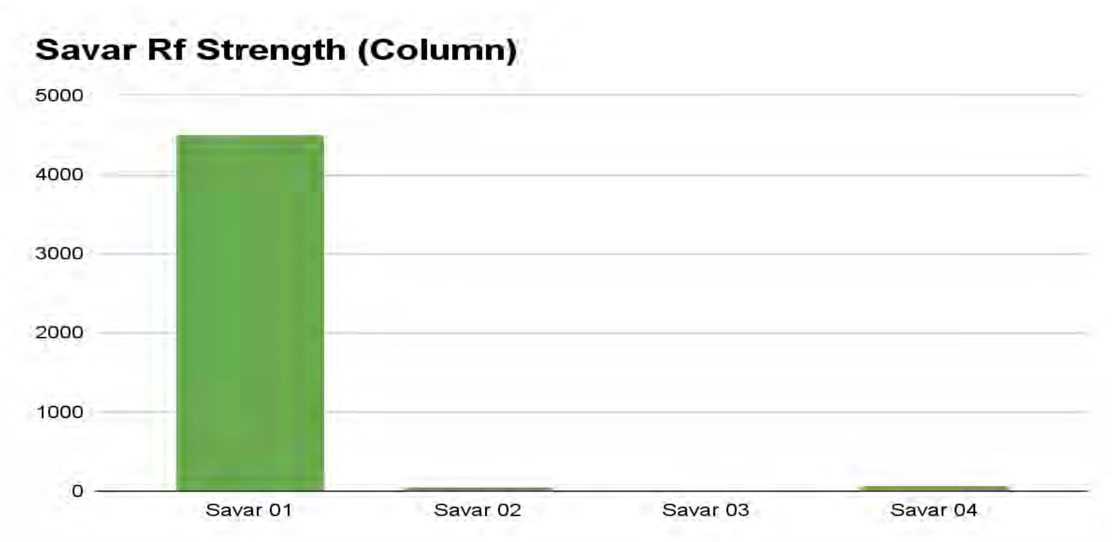


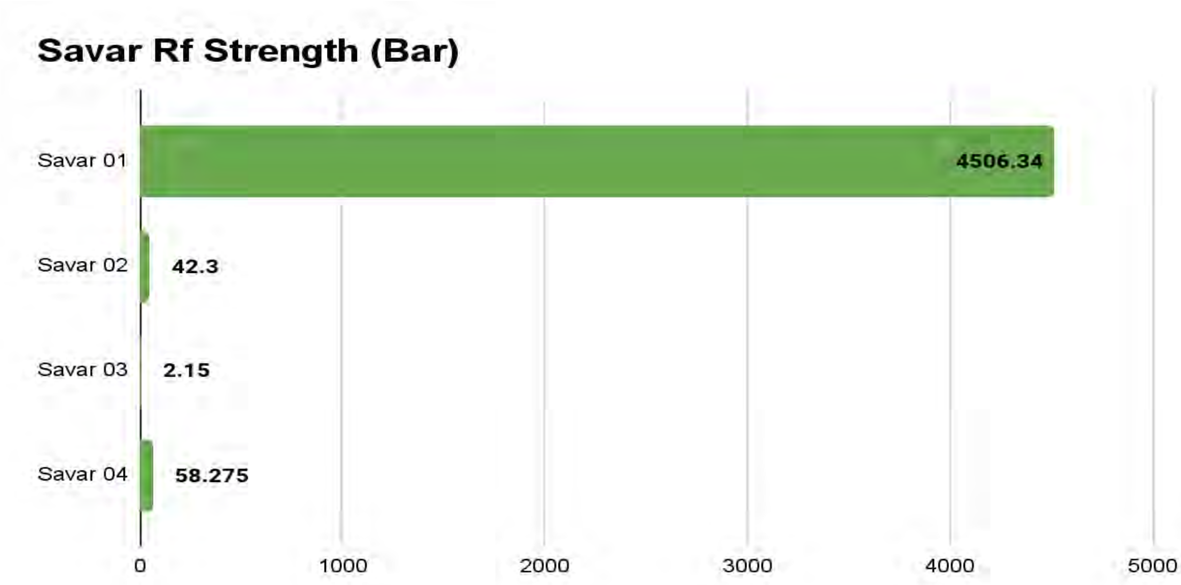




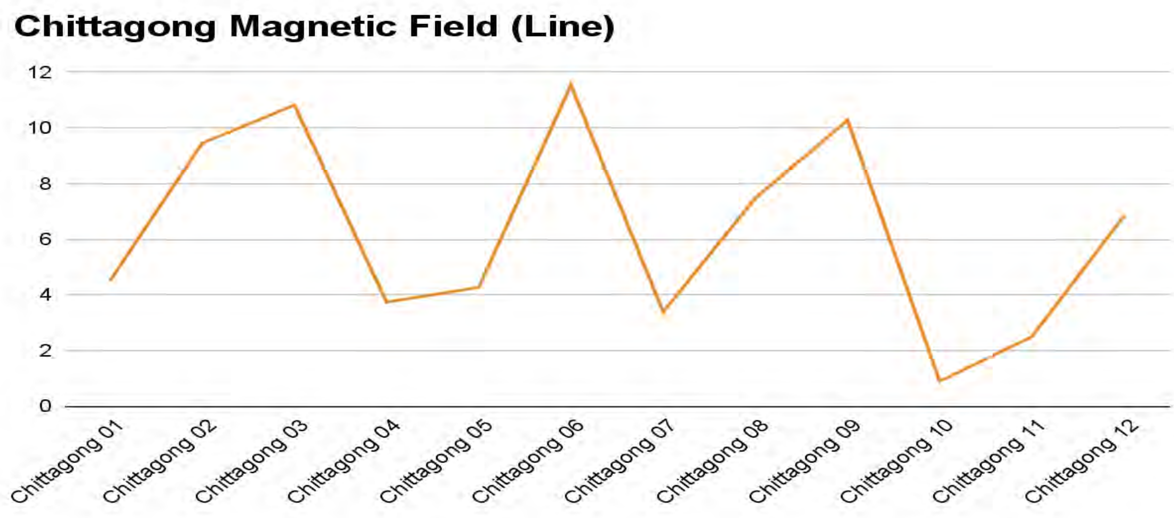
In Savar, the data from the two cell towers shows that while the emissions were close to the optimal range, they still exceeded it, recording values of 6 V/m and 8 V/m. For the HVTL towers, one recorded an electric field of 6.75 V/m, while the other reached 111 V/m, both of which were below the standard allowable range. The electric field data from both cell towers and HVTL towers in Savar is visualized using a variety of graphs for comparison and trend analysis.

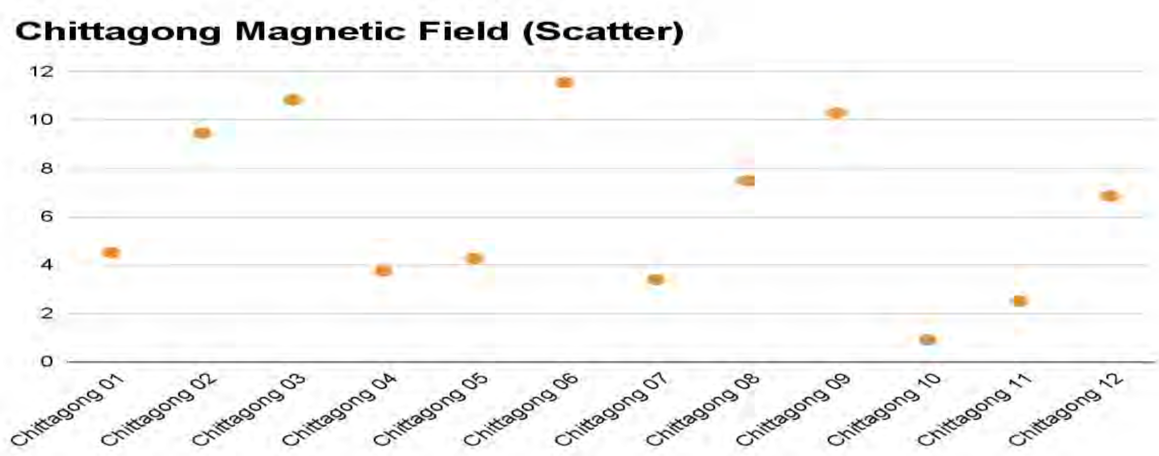


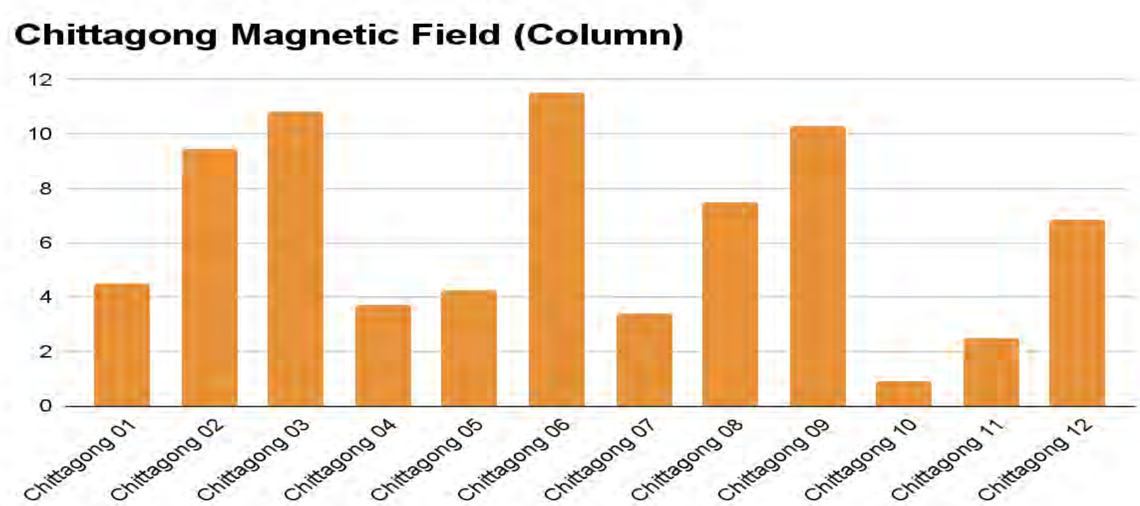


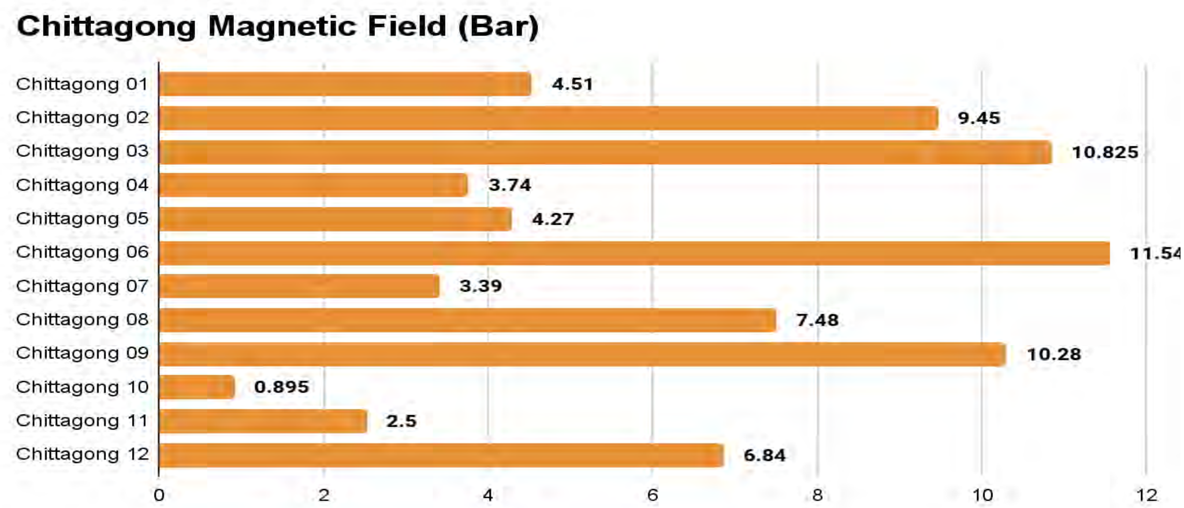


The radio frequency (RF) emissions from both cell towers and HVTL towers were compared using bar, line, column, and scatter graphs. These visualizations make it easy to identify differences, track changes over time, and assess compliance with safety standards. From the collected data, the two cell towers remained within the optimal range of below 45 µW/m², with values of 2.15 µW/m² and 42.3 µW/m². In contrast, the two HVTL towers recorded much higher RF emissions, at 4506.34 µW/m² and 58.275 µW/m², respectively.

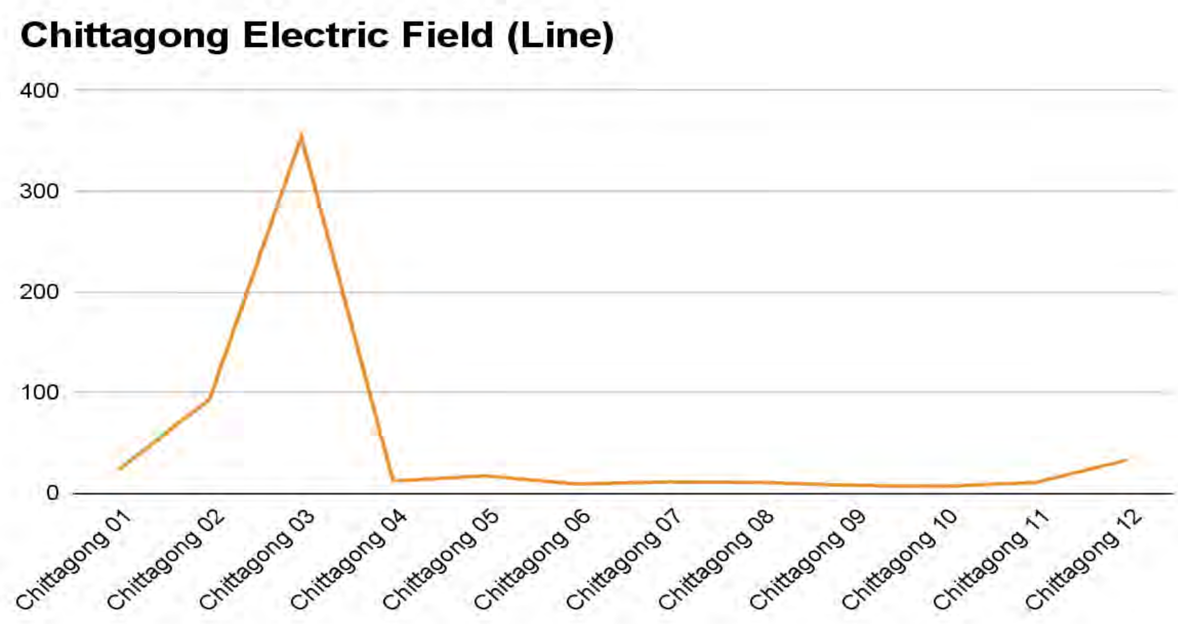

Chittagong Magnetic Field (Line)
12
10
8
6
4
2
0
Chittagong 01
Chittagong 02
Chittagong 03
Chittagong 04
Chittagong 05
Chittagong 06
Chittagong 07
Chittagong 08
Chittagong 09
Chittagong 10
Chittagong 11
Chittagong 12

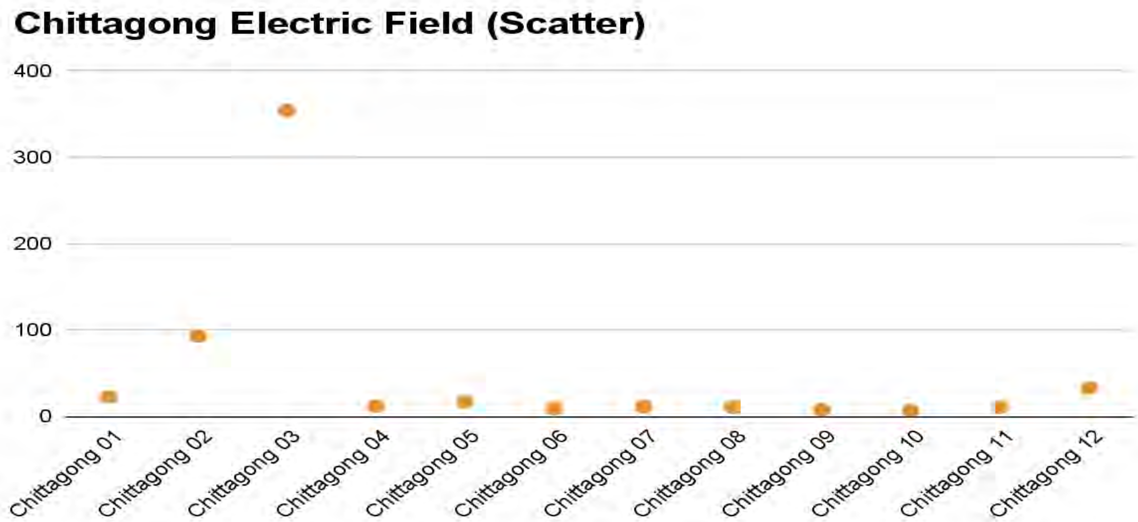

Chittagong Magnetic Field (Scatter)
12
10
8
6
4
2
0
Chittagong 01
Chittagong 02
Chittagong 03
Chittagong 04
Chittagong 05
Chittagong 06
Chittagong 07
Chittagong 08
Chittagong 09
Chittagong 10
Chittagong 11
Chittagong 12

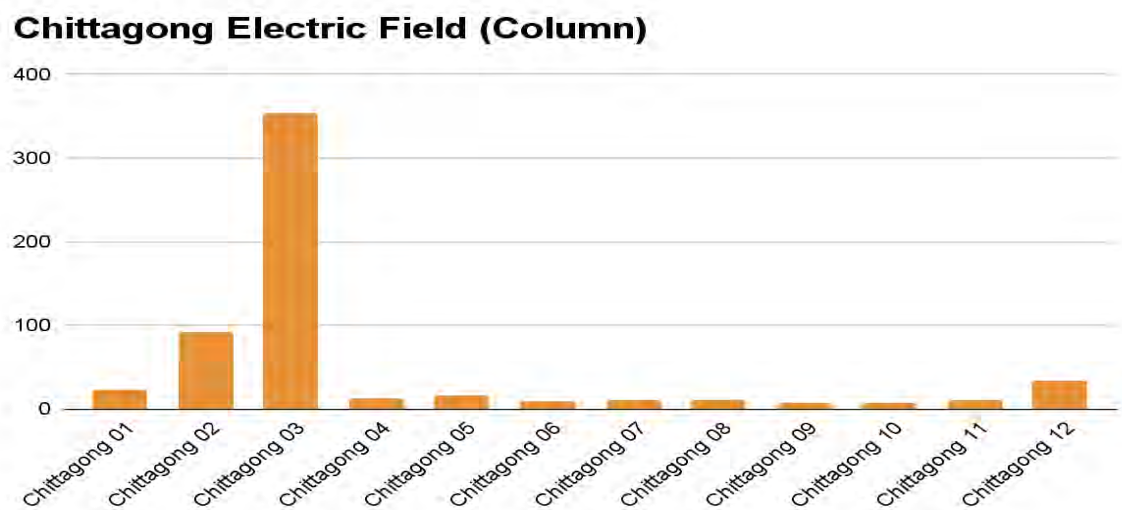

Chittagong Magnetic Field (Column)
12
10
8
6
4
2
0
Chittagong 01
Chittagong 02
Chittagong 03
Chittagong 04
Chittagong 05
Chittagong 06
Chittagong 07
Chittagong 08
Chittagong 09
Chittagong 10
Chittagong 11
Chittagong 12

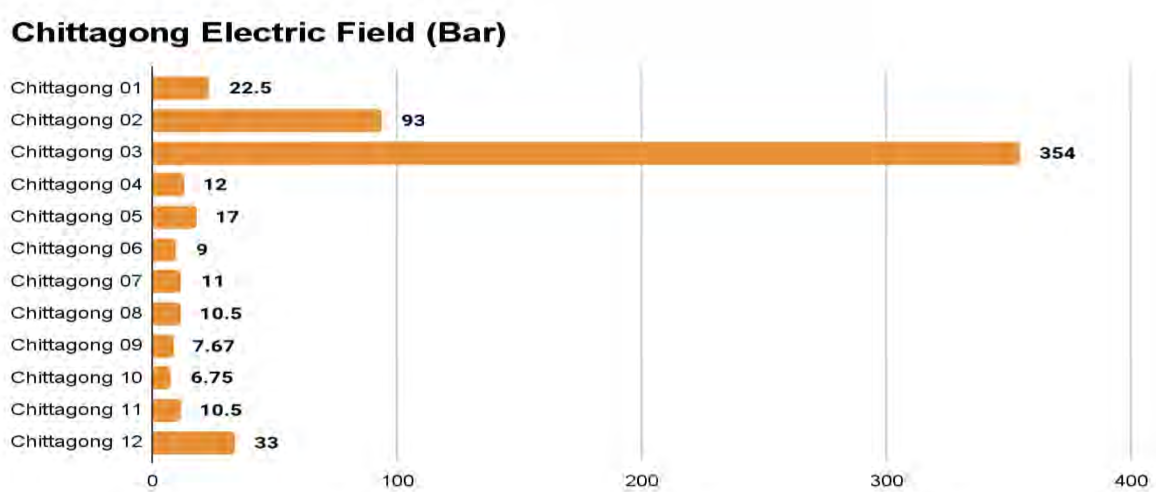


Magnetic field intensities from cell towers and HVTL towers in Chittagong were analyzed using bar, line, column, and scatter graphs. The bar graph shows the differences in emission levels between the two types, while the line graph tracks fluctuations over time. The column graph compares average values against safety thresholds, and the scatter graph illustrates any correlations between magnetic field intensities across locations. For HVTL towers, emissions from Towers 2, 3, 6, and 9 remained safely within the range of 1 to 200 milligauss (mG). However, the cell towers exceeded the safety threshold of 0.1 mG, indicating a potential concern

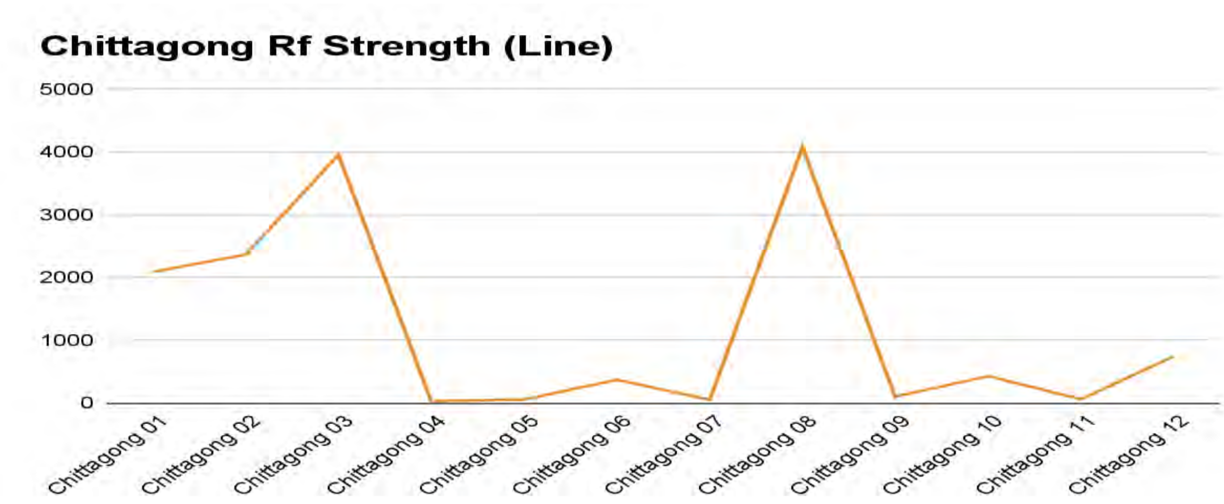


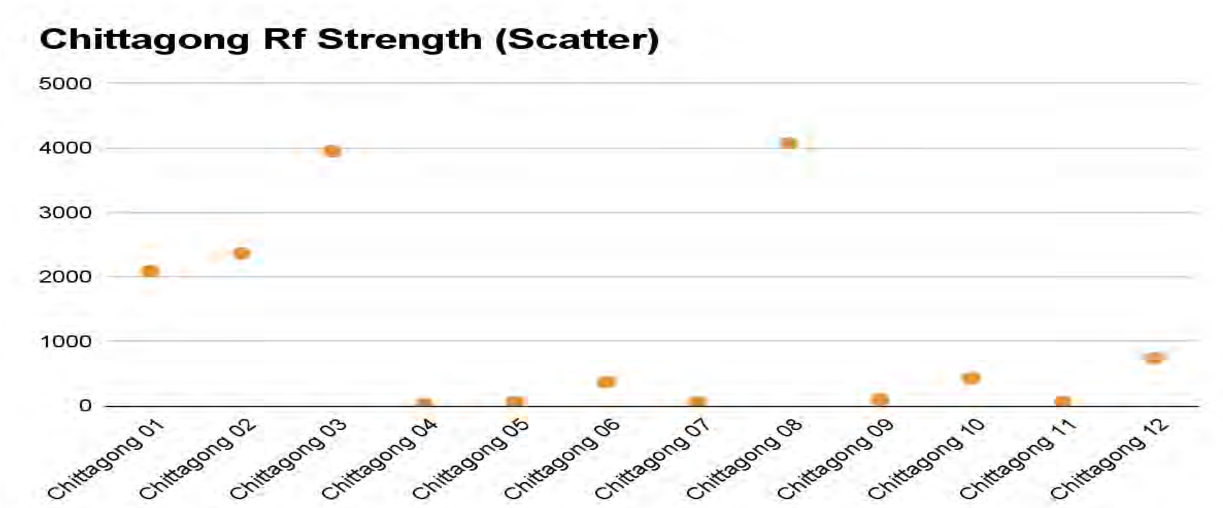

Chittagong Electric Field (Scatter)
400
300
200
100
0
Chittagong 01
Chittagong 02
Chittagong 03
Chittagong 04
Chittagong 05
Chittagong 06
Chittagong 07
Chittagong 08
Chittagong 09
Chittagong 10
Chittagong 11
Chittagong 12

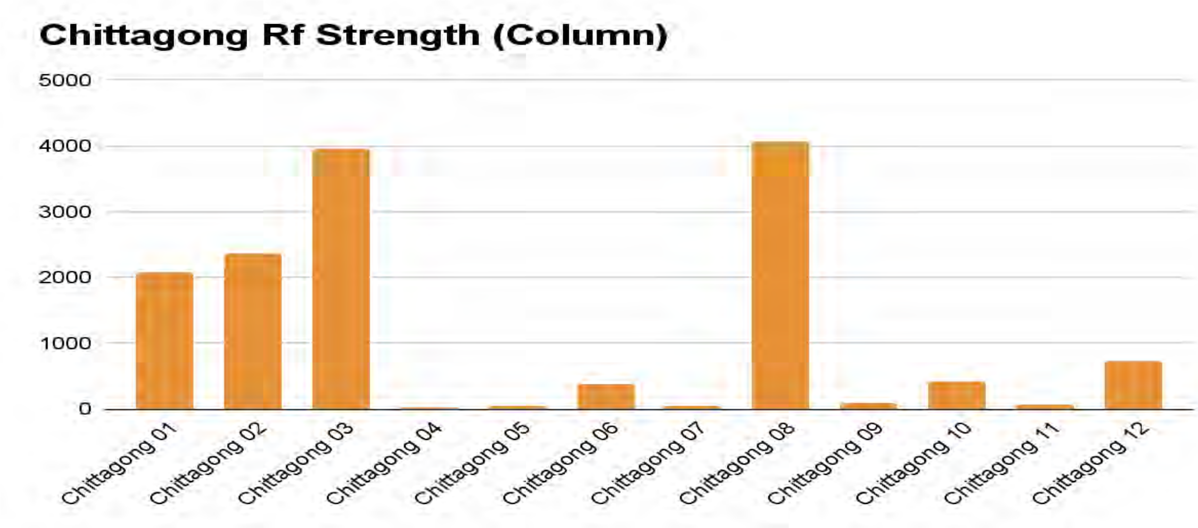

Chittagong Electric Field (Column)
400
300
200
100
0
Chittagong 01
Chittagong 02
Chittagong 03
Chittagong 04
Chittagong 05
Chittagong 06
Chittagong 07
Chittagong 08
Chittagong 09
Chittagong 10
Chittagong 11
Chittagong 12

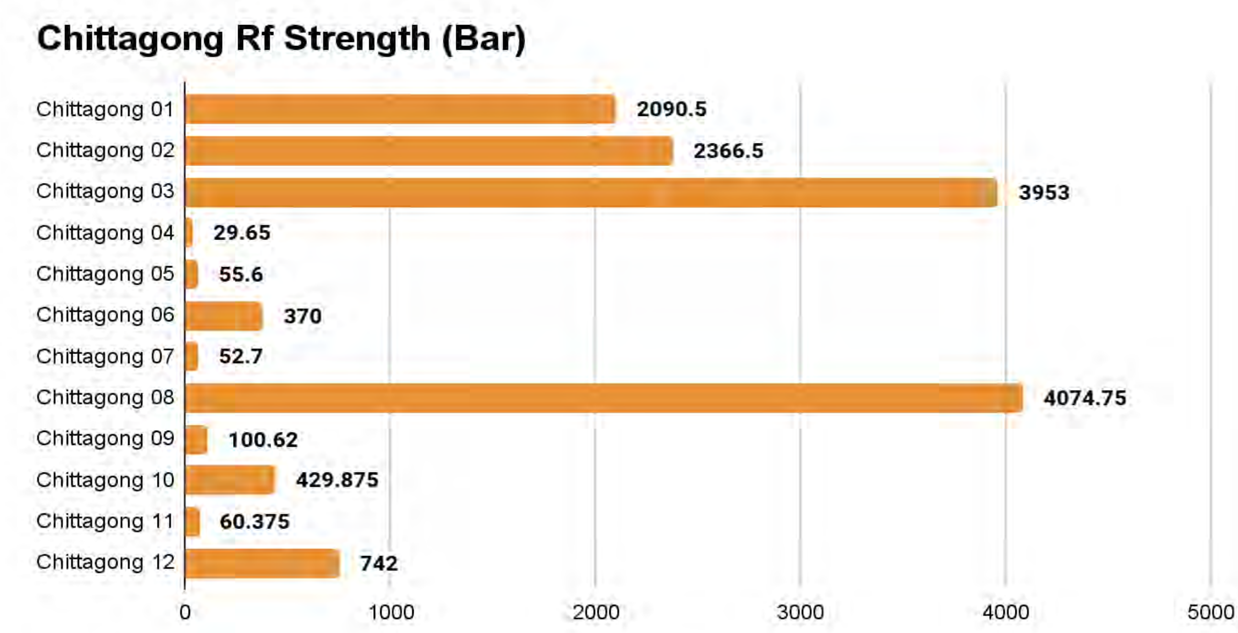

Chittagong Electric Field (Bar)
Chittagong 01
22.5
Chittagong 02
93
Chittagong 03
354
Chittagong 04
12
Chittagong 05
17
Chittagong 06
9
Chittagong 07
11
Chittagong 08
10.5
Chittagong 09
7.67
Chittagong 10
6.75
Chittagong 11
10.5
Chittagong 12
33
0
100
200
300
400

The electric field data from cell towers and HVTL towers in Chittagong is presented using a combination of bar, line, column, and scatter graphs to facilitate comparison and trend analysis. The bar graph compares the electric field levels, while the line graph tracks variations over time. The column graph highlights any exceedances of standard safety limits, and the scatter graph explores relationships between emission levels across locations. Both cell towers and HVTL towers in Chittagong emitted non-ionizing radiation (NIR) with electric field strengths exceeding the standard values of 5 V/m and 10 kV/m, respectively. Towers 02 and 03 stood out for emitting the highest levels of NIR.

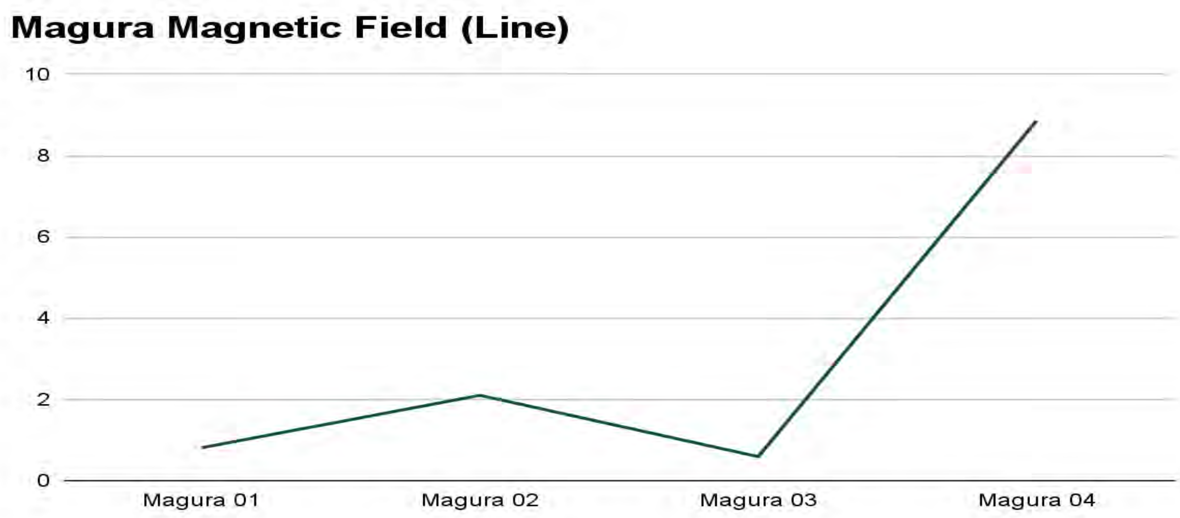


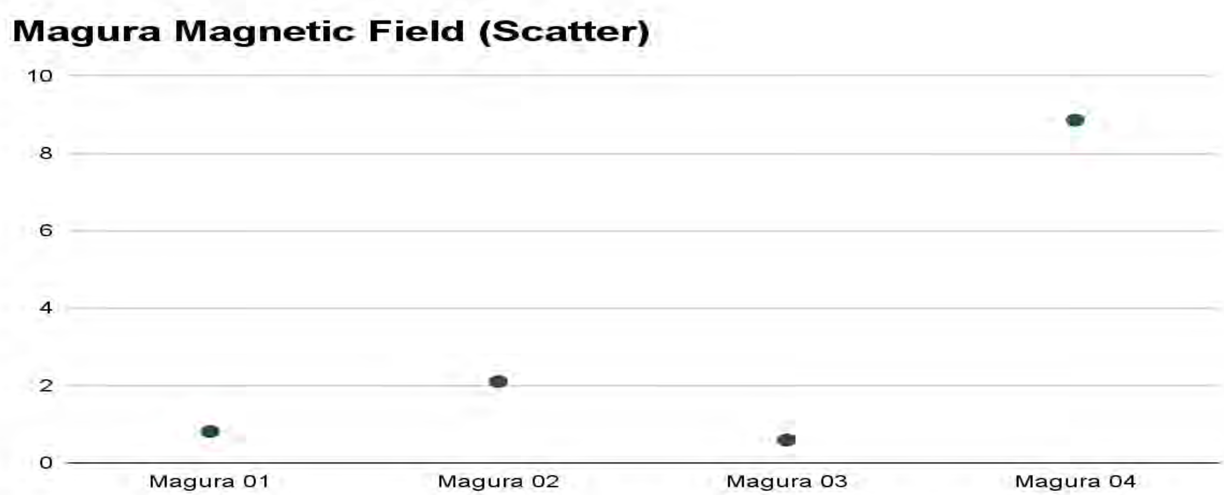


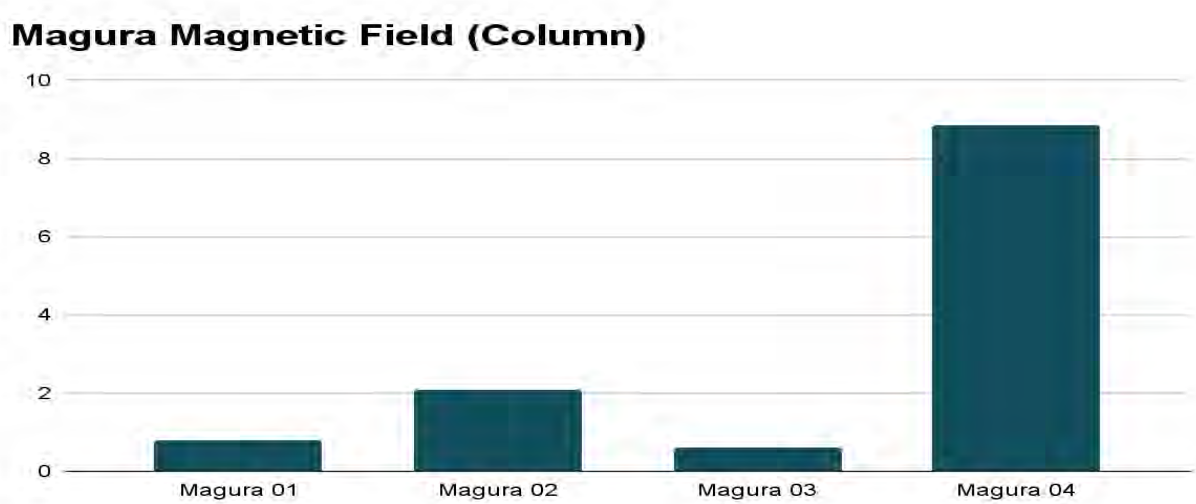


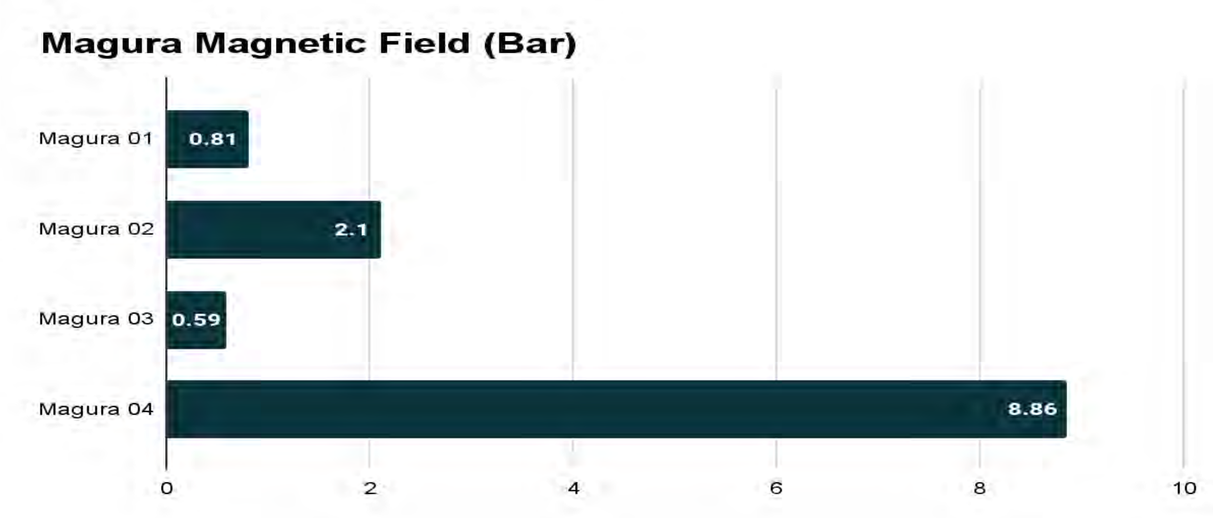


The radio frequency (RF) emissions from both cell towers and HVTL towers are compared through bar, line, column, and scatter graphs. The bar graph provides an easy comparison of RF strength, while the line graph tracks changes over time, revealing patterns or spikes. The column graph contrasts average RF values against safety standards, and the scatter graph visualizes relationships between RF strength, tower type, and location. From the data collected from 3 cell towers and 9 HVTL towers, only 4 towers were close to the safety range. The rest significantly exceeded it, with Tower 8 recording the highest emission at 4074.75 $\mu W/m^2$, and Towers 1, 2, and 3 following with emissions of 2090.5 $\mu W/m^2$, 2366.5 $\mu W/m^2$, and 3953 $\mu W/m^2$, respectively.

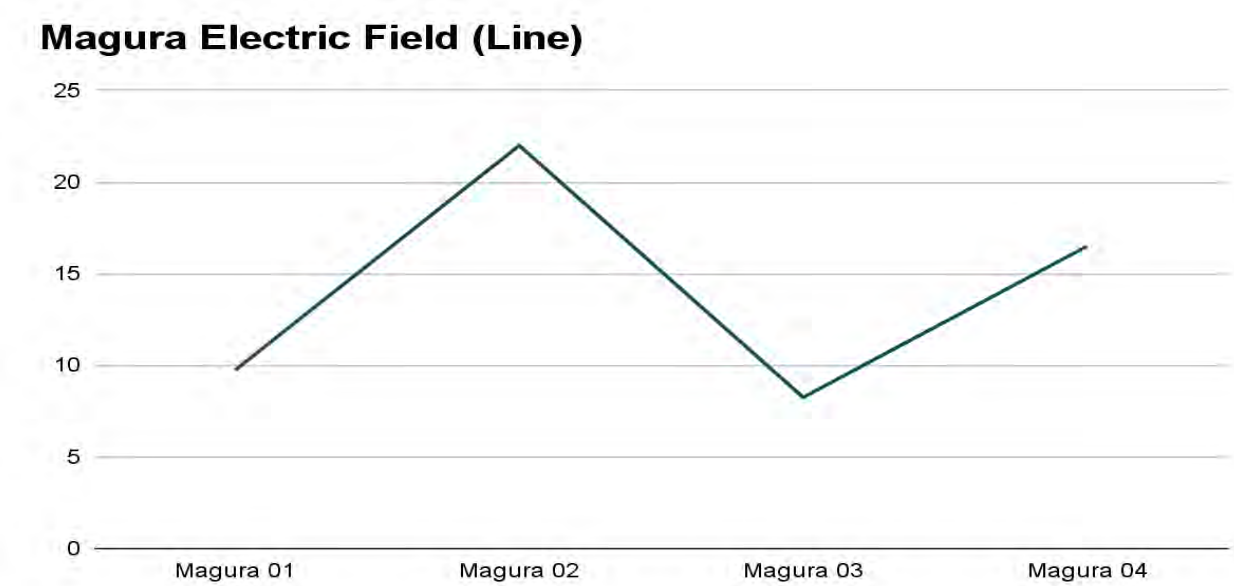

Magura Magnetic Field (Line)
10
8
6
4
2
0
Magura 01
Magura 02
Magura 03
Magura 04

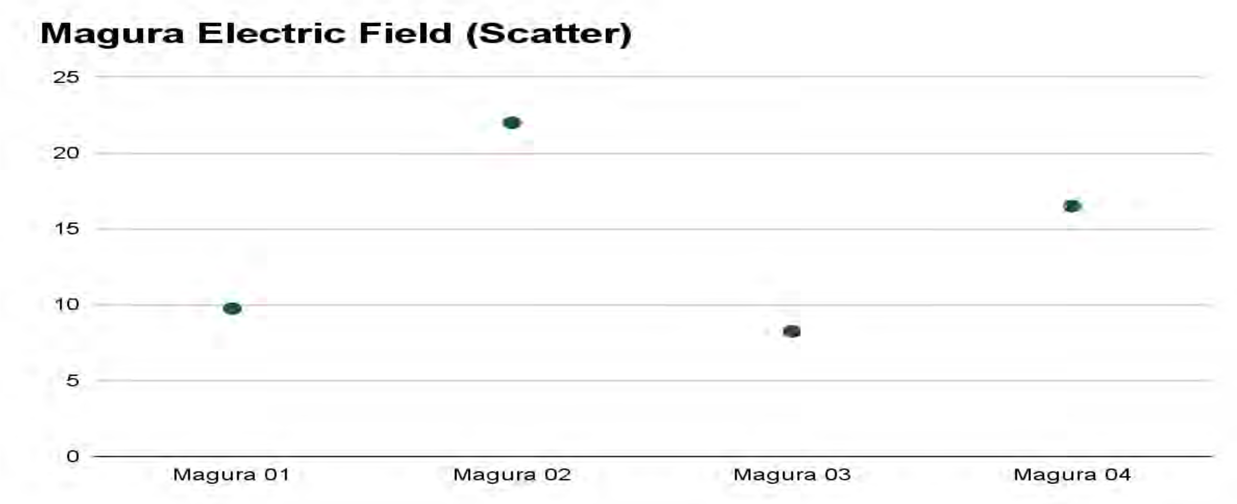

Magura Magnetic Field (Scatter)
10
8
6
4
2
0
Magura 01
Magura 02
Magura 03
Magura 04

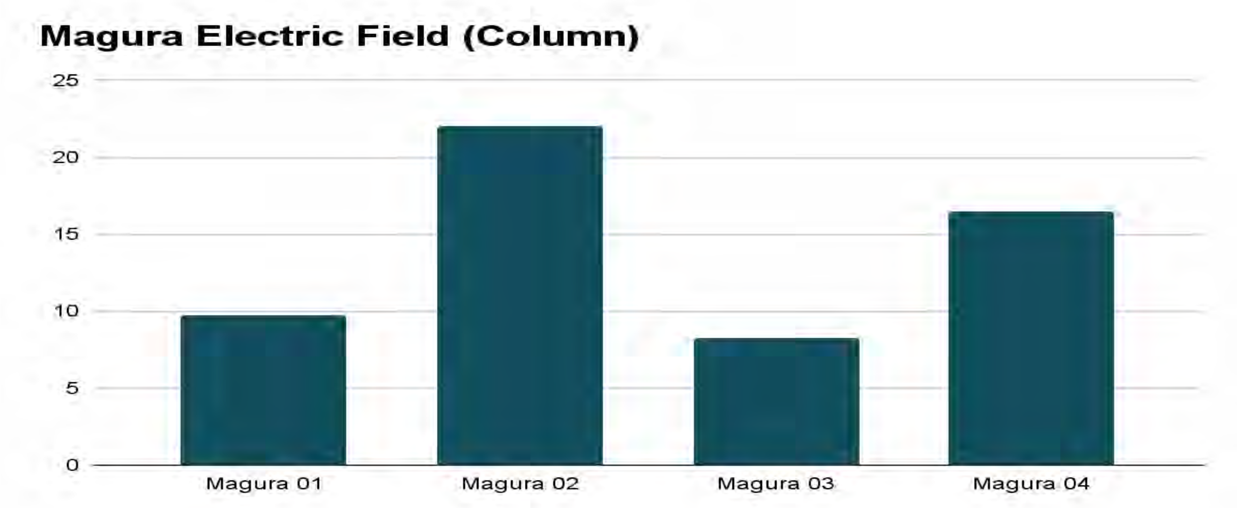

Magura Magnetic Field (Column)
10
8
6
4
2
0
Magura 01
Magura 02
Magura 03
Magura 04

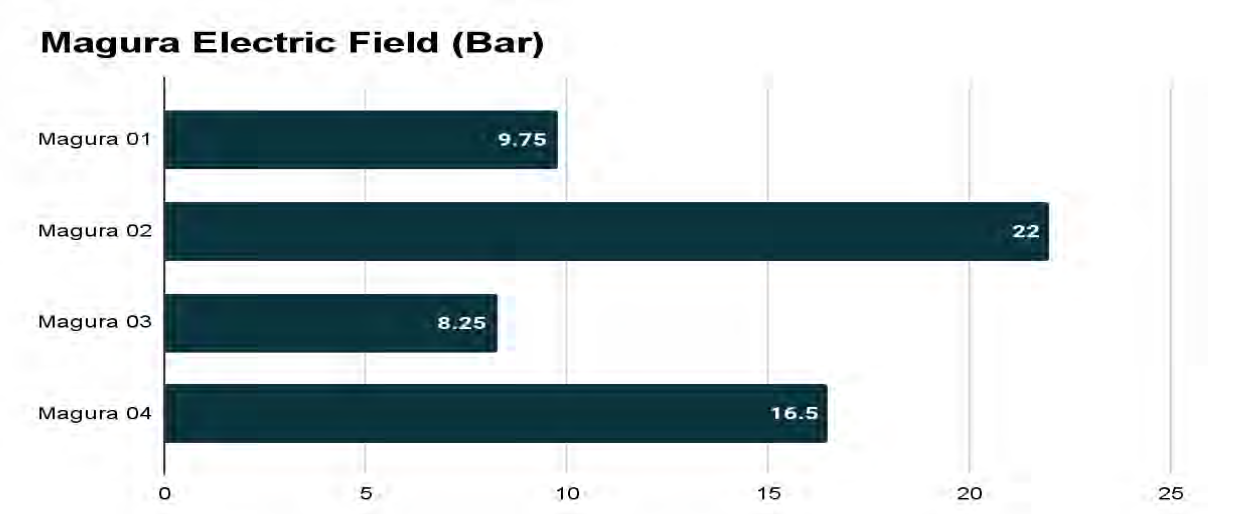


The magnetic field intensities from cell towers in Magura are displayed using bar, line, column, and scatter graphs. The bar graph highlights the differences in emissions between the two tower types, while the line graph shows fluctuations over time. The column graph compares the average magnetic field values to safety standards, offering a clear view of compliance, and the scatter graph examines potential correlations between emission levels across various locations. In Magura, cell towers were found to exceed the safe magnetic field limit of 0.1 mG, with the highest reading reaching 8.86 mG.

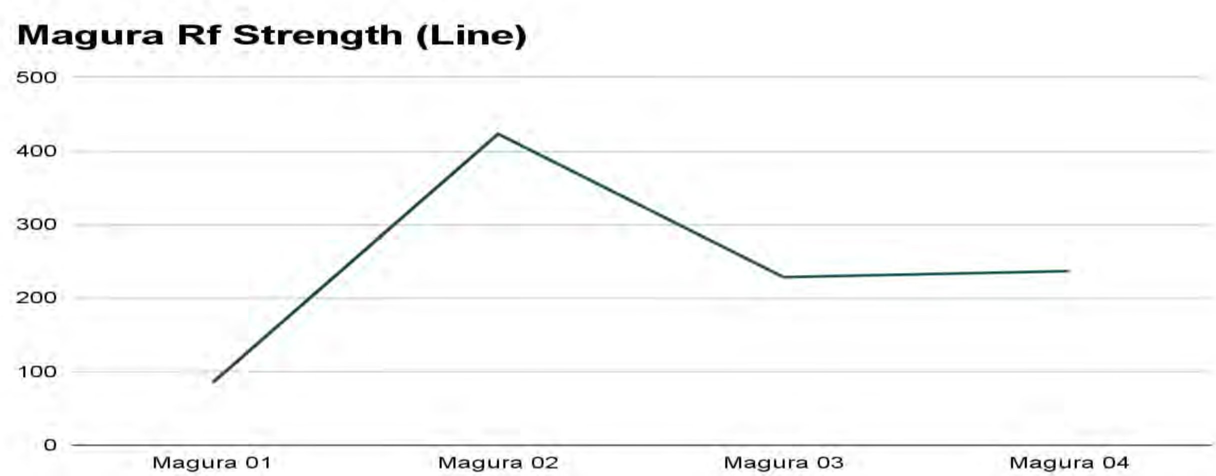


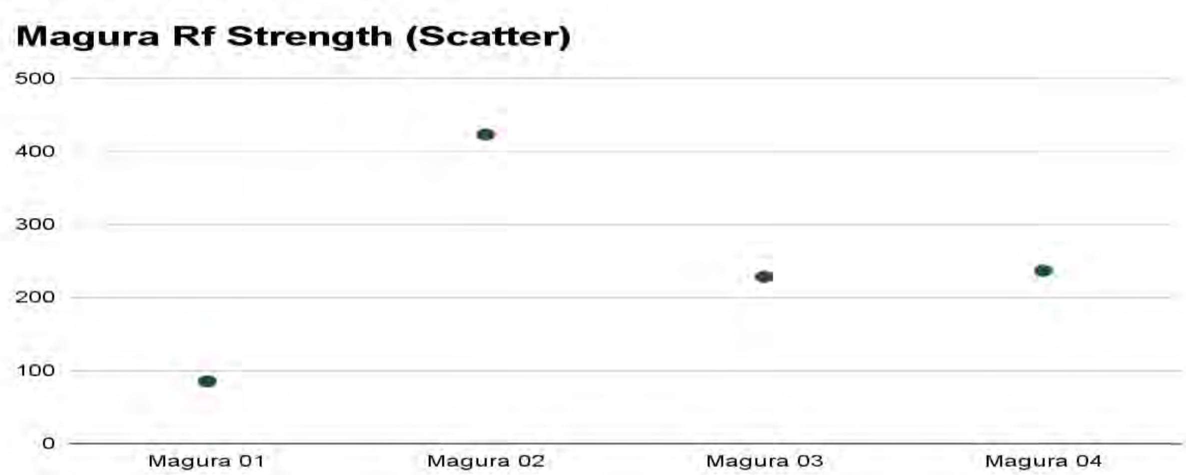


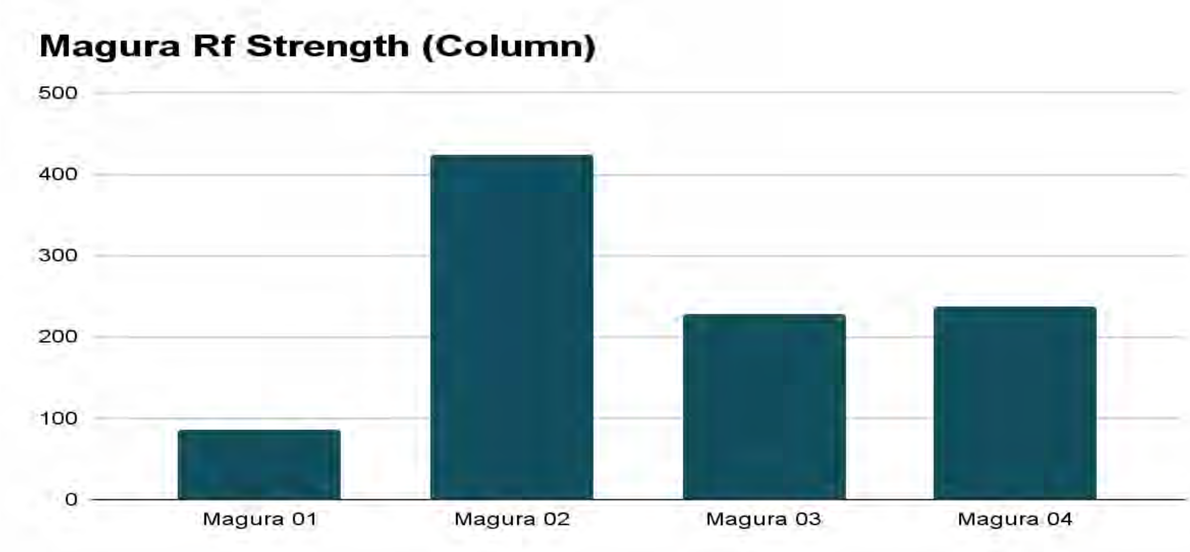


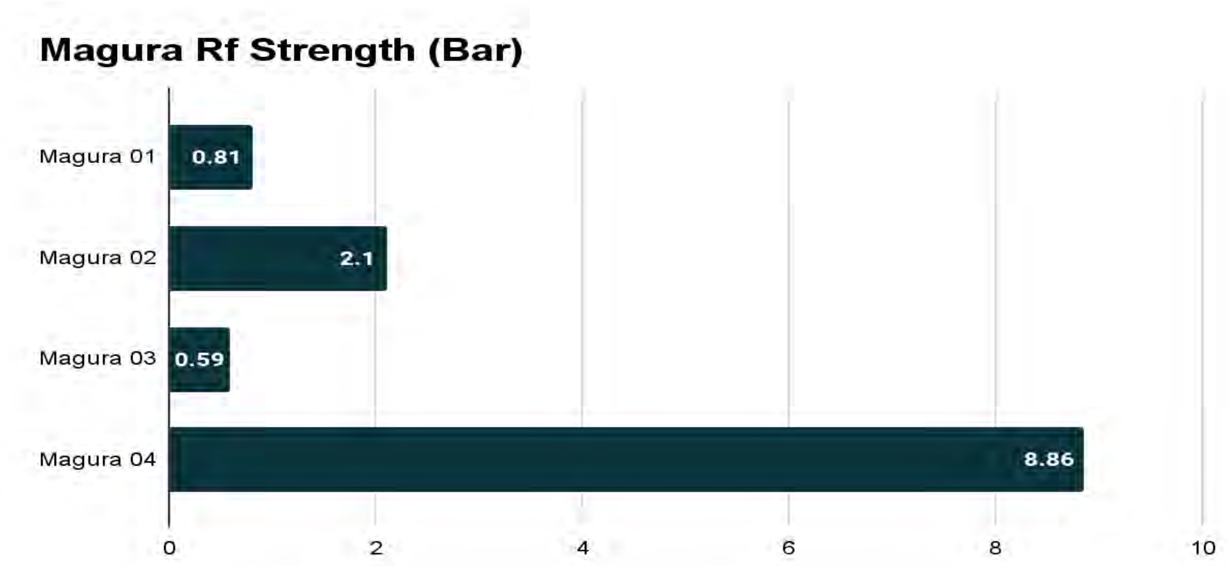


The electric field data is also displayed using a combination of graphs to enhance comparison and trend analysis. The bar graph provides a direct comparison of electric field levels between the cell towers and HVTL towers, showing their respective emission strengths. The line graph demonstrates the variation of electric field intensities over time. Meanwhile, the column graph compares the average electric field values to the standard allowable limits, making it easy to identify if any towers exceed safety thresholds. The scatter graph helps in analyzing possible relationships between electric field intensities in different areas. In terms of the electric field, all of the 4 cell towers also crossed the safety range of 0.5 to 5 V/m with 22 V/m being the highest one

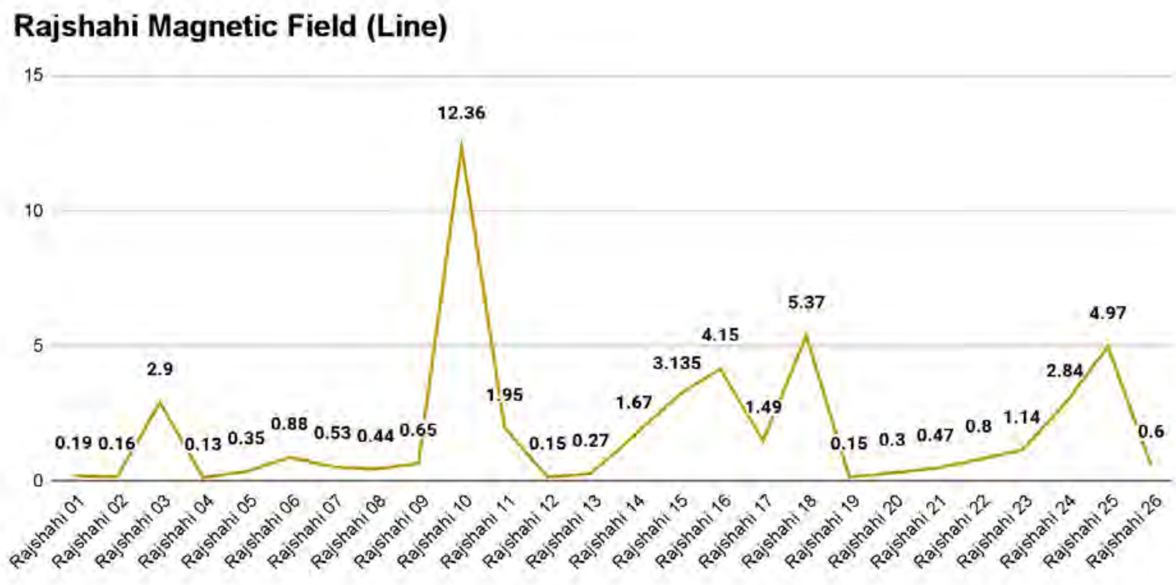


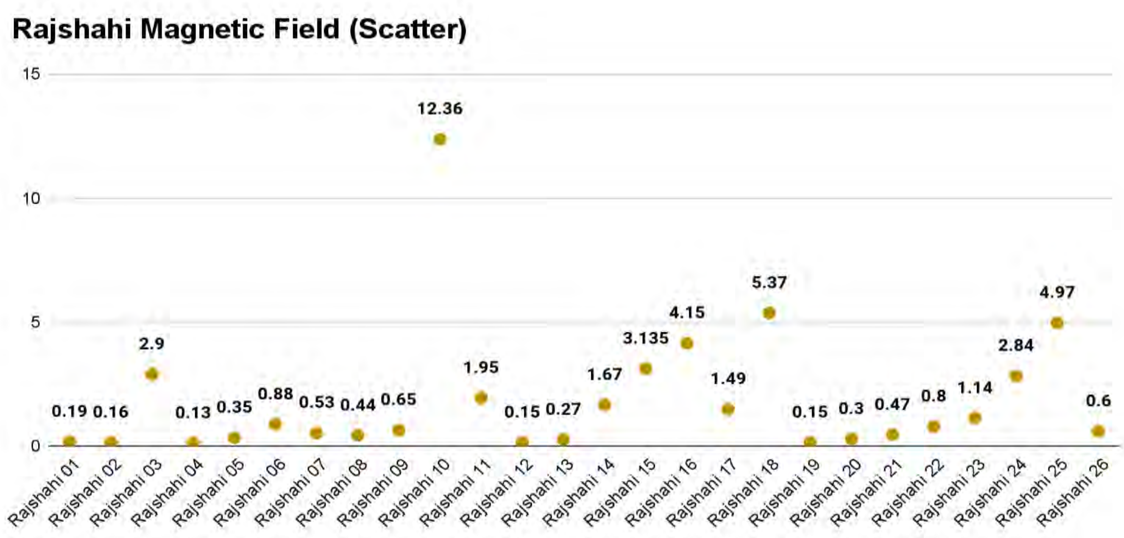






The radio frequency (RF) emissions from cell towers in Magura are visualized through four different graphs. The **bar graph** presents a clear comparison of RF strengths across the towers, while the **line graph** monitors RF exposure over time, revealing any significant patterns or fluctuations. The **column graph** compares the average RF levels to established safety limits, quickly identifying any instances where the values exceed those standards. Among the 4 cell towers measured from Magura, only tower 1, (0.81) was in the closest to the safety range of radio frequency. The highest emission was found from tower 2 which was 423.34 µW/m^2**.**


Rajshahi Magnetic Field (Line)
15
10
5
0
12.36
5.37
4.97
4.15
3.135
2.9
2.84
1.95
1.67
1.49
1.14
0.19 0.16
0.13 0.35
0.88
0.53 0.44 0.65
0.15 0.27
0.15 0.3 0.47 0.8
0.6
Rajshahi 01
Rajshahi 02
Rajshahi 03
Rajshahi 04
Rajshahi 05
Rajshahi 06
Rajshahi 07
Rajshahi 08
Rajshahi 09
Rajshahi 10
Rajshahi 11
Rajshahi 12
Rajshahi 13
Rajshahi 14
Rajshahi 15
Rajshahi 16
Rajshahi 17
Rajshahi 18
Rajshahi 19
Rajshahi 20
Rajshahi 21
Rajshahi 22
Rajshahi 23
Rajshahi 24
Rajshahi 25
Rajshahi 26


Rajshahi Magnetic Field (Scatter)
15
10
5
0
12.36
5.37
4.97
4.15
3.135
2.9
2.84
1.95
1.67
1.49
1.14
0.19 0.16
0.13 0.35
0.88
0.53 0.44 0.65
0.15 0.27
0.15 0.3 0.47 0.8
0.6
Rajshahi 01
Rajshahi 02
Rajshahi 03
Rajshahi 04
Rajshahi 05
Rajshahi 06
Rajshahi 07
Rajshahi 08
Rajshahi 09
Rajshahi 10
Rajshahi 11
Rajshahi 12
Rajshahi 13
Rajshahi 14
Rajshahi 15
Rajshahi 16
Rajshahi 17
Rajshahi 18
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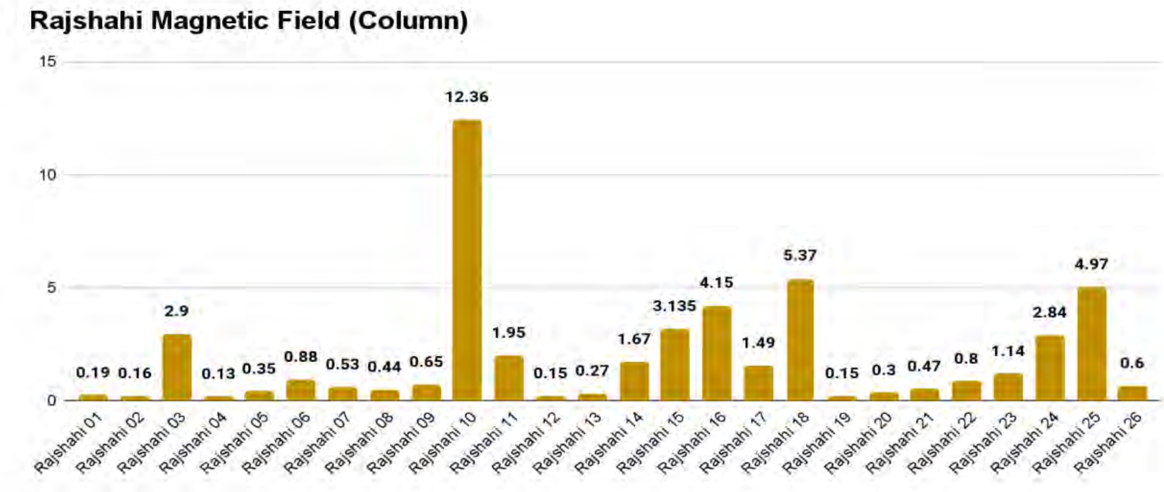
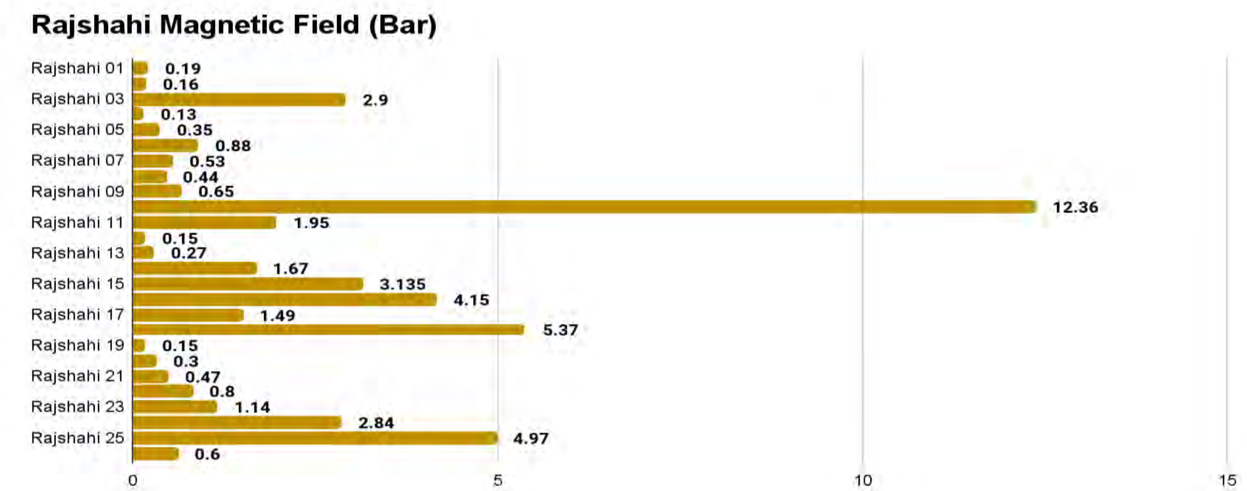
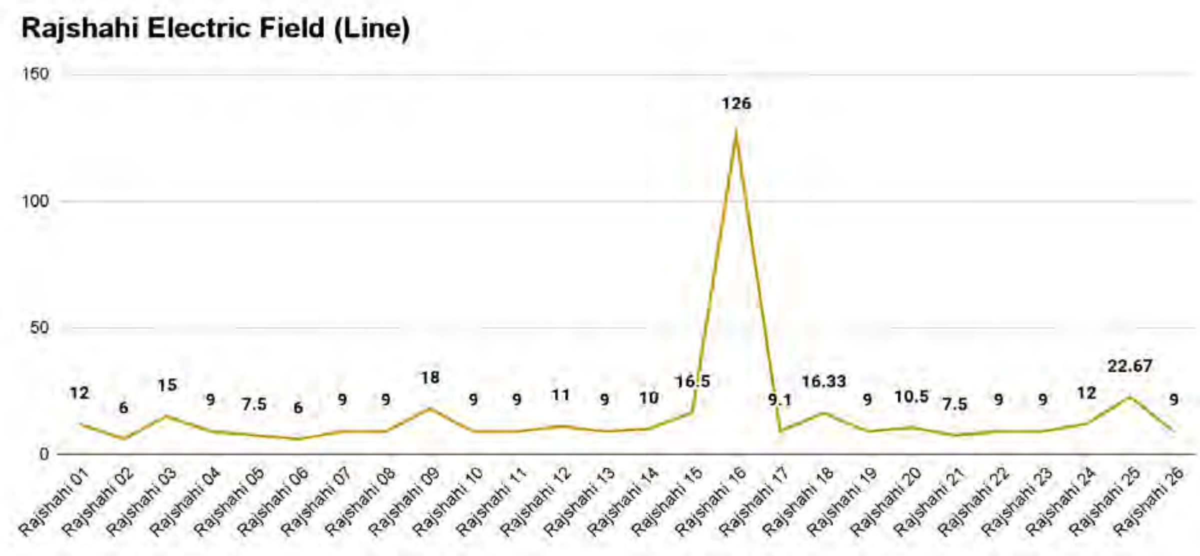
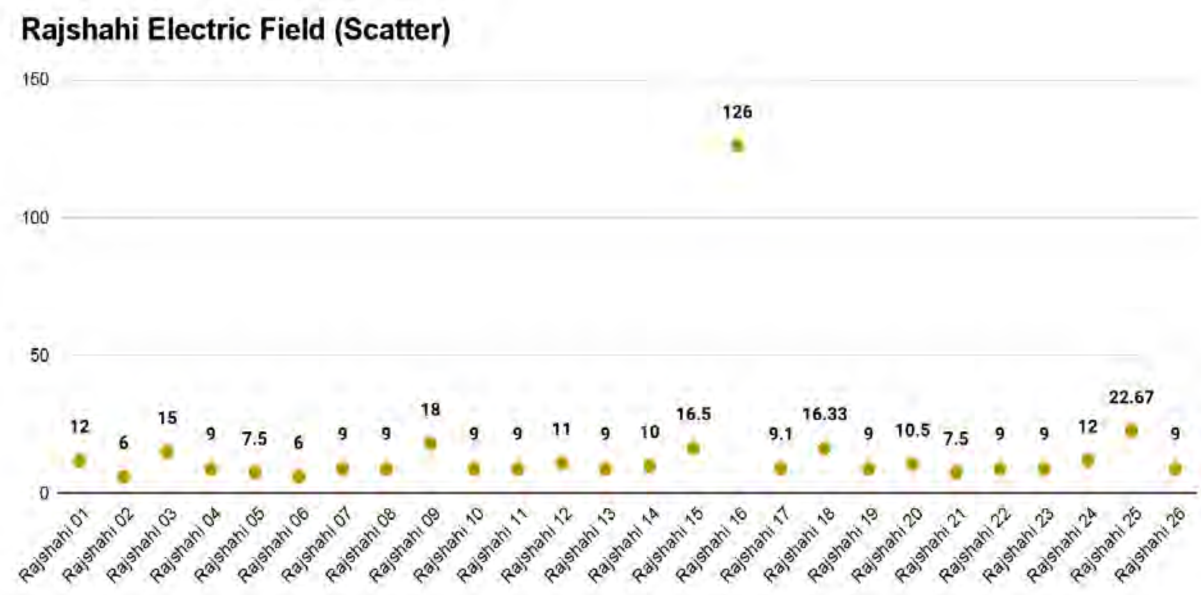
Rajshahi 20
Rajshahi 21
Rajshahi 22
Rajshahi 23
Rajshahi 24
Rajshahi 25
Rajshahi 26





The magnetic field intensities from both cell towers and HVTL towers are displayed using bar, line, column, and scatter graphs. The bar graph shows the differences in magnetic field emissions between the two types of towers, while the line graph captures how the emissions fluctuate over time. The column graph compares the average magnetic field values with safety standards, offering a quick reference for compliance. Finally, the scatter graph examines the correlations between magnetic field intensities across various locations. The results were varied, with some towers emitting levels close to the safety range and others further from it. Towers 1, 2, 4, 12, and 19 were nearest to the safe limit, with Tower 4 recording the lowest at 0.13 mG. The highest emission came from Tower 10, with a reading of 12.36 mG.


Rajshahi Electric Field (Line)
150
100
50
0
126
12
6
15
9
7.5
6
9
9
18
9
9
11
9
10
16.5
9.1
16.33
9
10.5
7.5
9
9
12
22.67
9
Rajshahi 01
Rajshahi 02
Rajshahi 03
Rajshahi 04
Rajshahi 05
Rajshahi 06
Rajshahi 07
Rajshahi 08
Rajshahi 09
Rajshahi 10
Rajshahi 11
Rajshahi 12
Rajshahi 13
Rajshahi 14
Rajshahi 15
Rajshahi 16
Rajshahi 17
Rajshahi 18
Rajshahi 19
Rajshahi 20
Rajshahi 21
Rajshahi 22
Rajshahi 23
Rajshahi 24
Rajshahi 25
Rajshahi 26


Rajshahi Electric Field (Scatter)
150
100
50
0
126
12
6
15
9
7.5
6
9
9
18
9
9
11
9
10
16.5
9.1
16.33
9
10.5
7.5
9
9
12
22.67
9
Rajshahi 01
Rajshahi 02
Rajshahi 03
Rajshahi 04
Rajshahi 05
Rajshahi 06
Rajshahi 07
Rajshahi 08
Rajshahi 09
Rajshahi 10
Rajshahi 11
Rajshahi 12
Rajshahi 13
Rajshahi 14
Rajshahi 15
Rajshahi 16
Rajshahi 17
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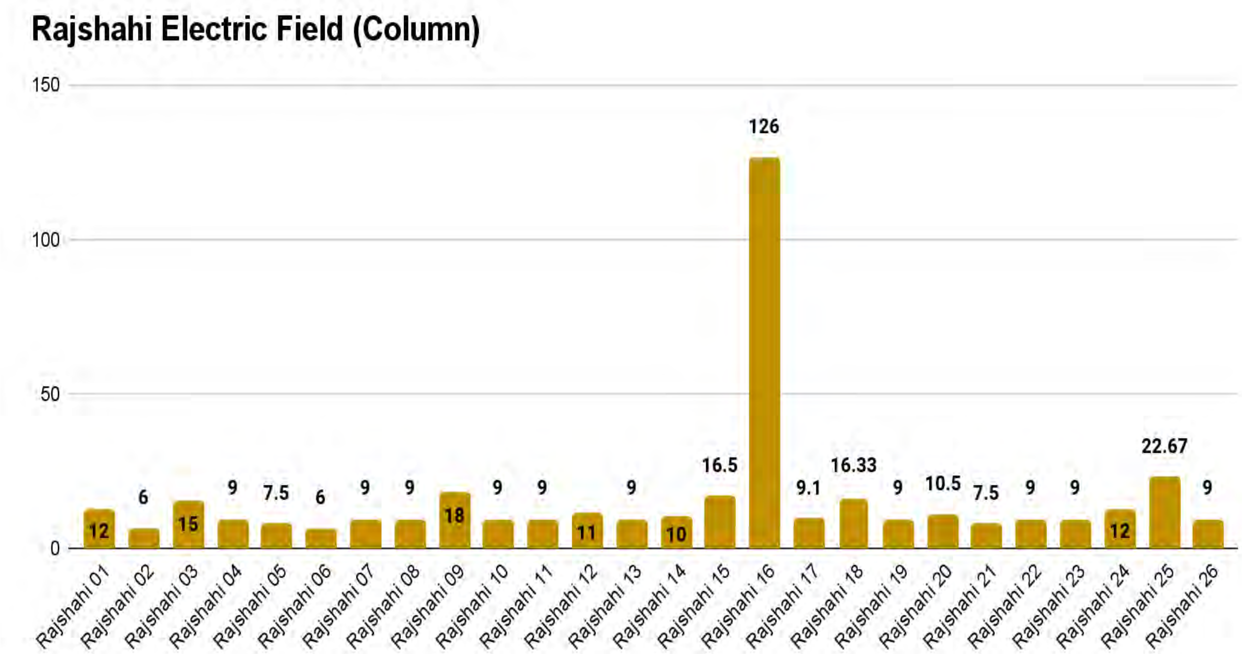
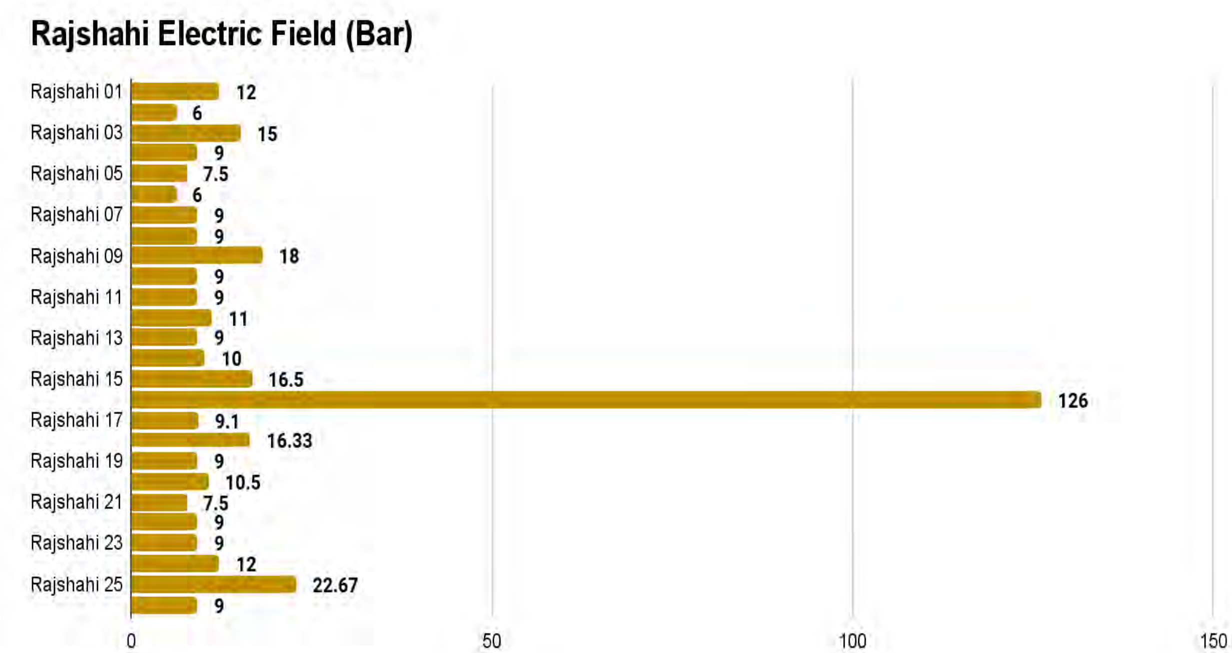
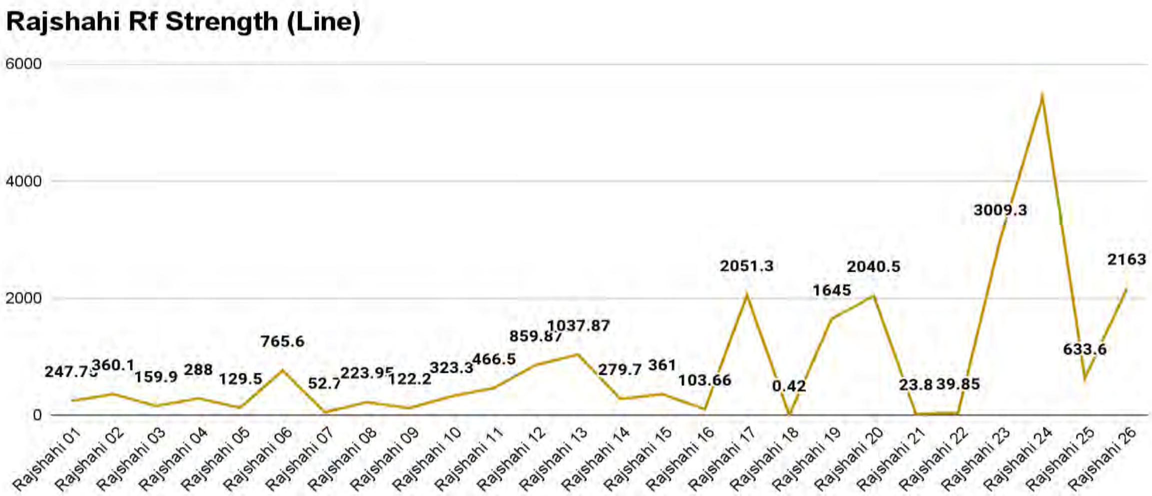
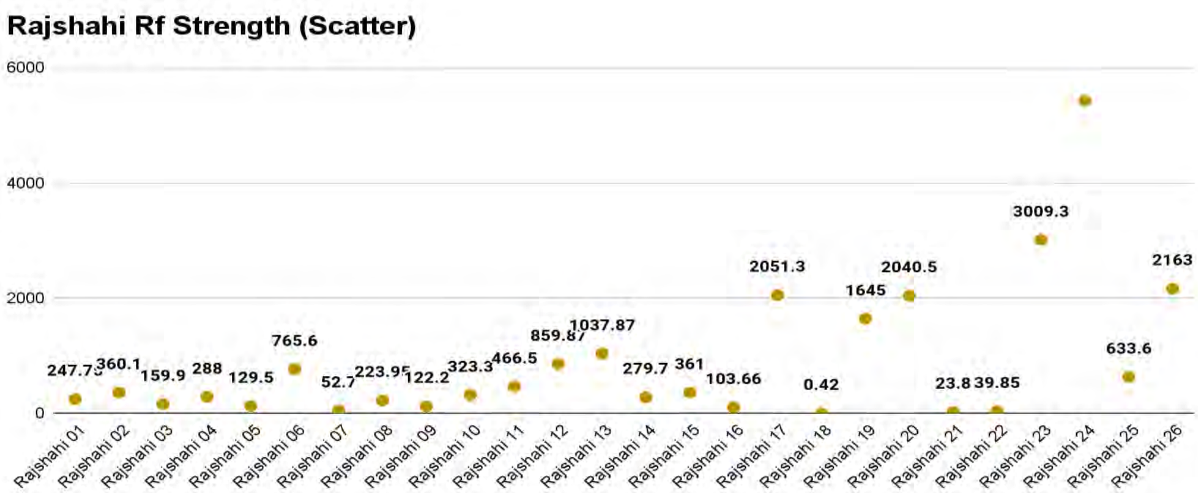
Rajshahi 25
Rajshahi 26

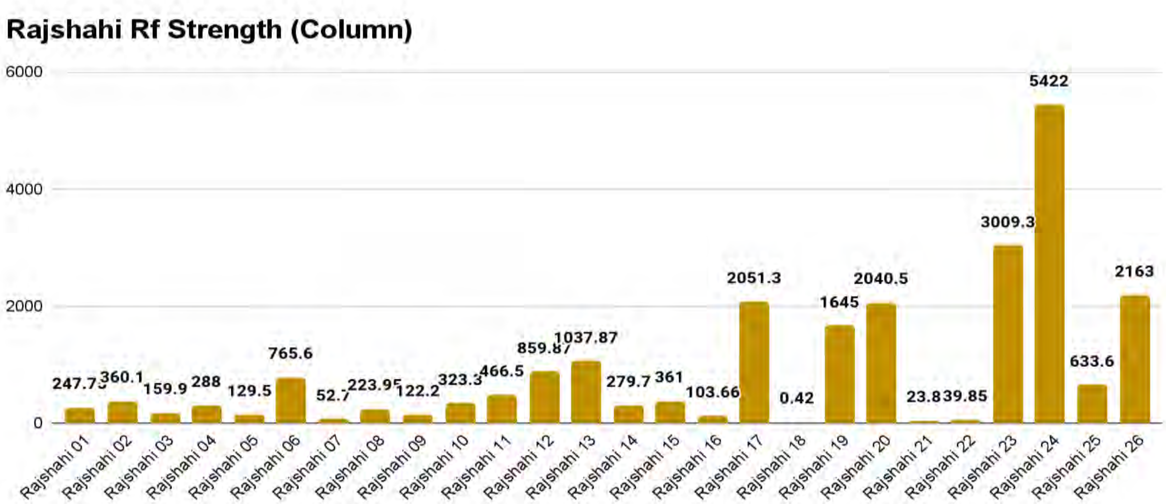


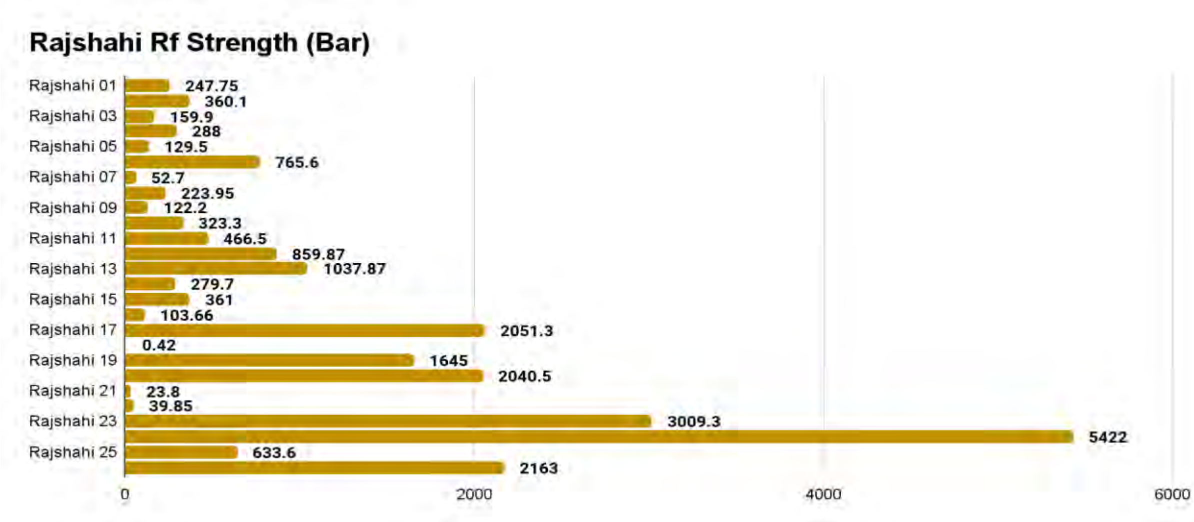


In terms of the electric field, most of the cell towers were in close range of the safety level of 0.5 V/m to 5 V/m, although none of them fell into the range. The closest being towers 2 and 6 with each being 6 V/m respectively. One of the two HVTL towers, tower no 16 to be specific, had the highest electric field emission with 126 V/m. This data is also displayed using a combination of graphs to enhance comparison and trend analysis.


Rajshahi Rf Strength (Line)
6000
4000
2000
0
247.73
360.1
159.9
288
129.5
765.6
52.7
223.95
122.2
323.3
466.5
859.87
1037.87
279.7
361
103.66
2051.3
0.42
1645
2040.5
23.8
39.85
3009.3
633.6
2163
Rajshahi 01
Rajshahi 02
Rajshahi 03
Rajshahi 04
Rajshahi 05
Rajshahi 06
Rajshahi 07
Rajshahi 08
Rajshahi 09
Rajshahi 10
Rajshahi 11
Rajshahi 12
Rajshahi 13
Rajshahi 14
Rajshahi 15
Rajshahi 16
Rajshahi 17
Rajshahi 18
Rajshahi 19
Rajshahi 20
Rajshahi 21
Rajshahi 22
Rajshahi 23
Rajshahi 24
Rajshahi 25
Rajshahi 26

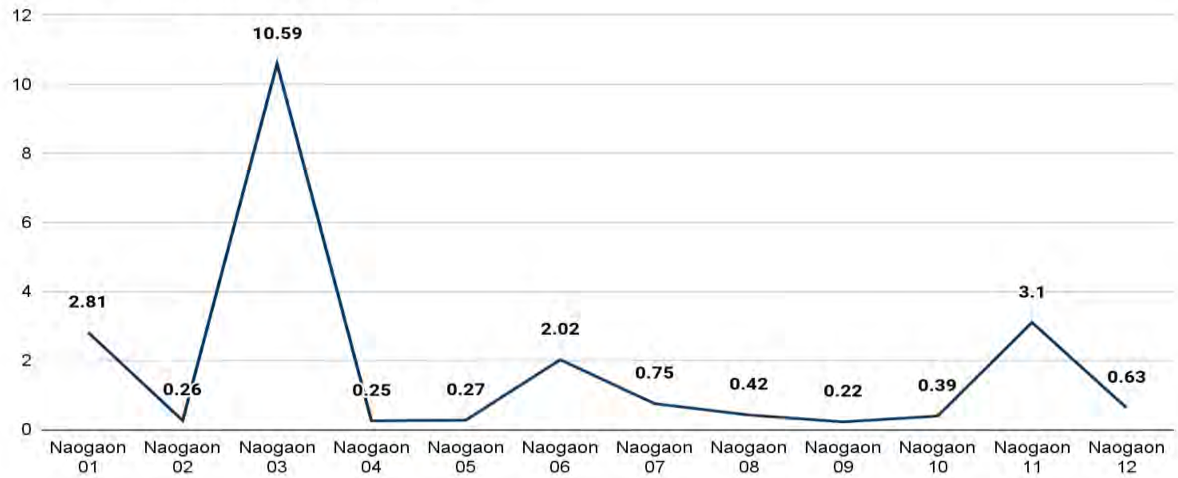

Rajshahi Rf Strength (Scatter)
6000
4000
2000
0
247.73
360.1
159.9
288
129.5
765.6
52.7
223.95
122.2
323.3
466.5
859.87
1037.87
279.7
361
103.66
2051.3
0.42
1645
2040.5
23.8
39.85
3009.3
633.6
2163
Rajshahi 01
Rajshahi 02
Rajshahi 03
Rajshahi 04
Rajshahi 05
Rajshahi 06
Rajshahi 07
Rajshahi 08
Rajshahi 09
Rajshahi 10
Rajshahi 11
Rajshahi 12
Rajshahi 13
Rajshahi 14
Rajshahi 15
Rajshahi 16
Rajshahi 17
Rajshahi 18
Rajshahi 19
Rajshahi 20
Rajshahi 21
Rajshahi 22
Rajshahi 23
Rajshahi 24
Rajshahi 25
Rajshahi 26


Rajshahi Rf Strength (Column)
6000
4000
2000
0
247.73
360.1
159.9
288
129.5
765.6
52.7
223.95
122.2
323.3
466.5
859.87
1037.87
279.7
361
103.66
2051.3
0.42
1645
2040.5
23.8
39.85
3009.3
5422
633.6
2163
Rajshahi 01
Rajshahi 02
Rajshahi 03
Rajshahi 04
Rajshahi 05
Rajshahi 06
Rajshahi 07
Rajshahi 08
Rajshahi 09
Rajshahi 10
Rajshahi 11
Rajshahi 12
Rajshahi 13
Rajshahi 14
Rajshahi 15
Rajshahi 16
Rajshahi 17
Rajshahi 18
Rajshahi 19
Rajshahi 20
Rajshahi 21
Rajshahi 22
Rajshahi 23
Rajshahi 24
Rajshahi 25
Rajshahi 26

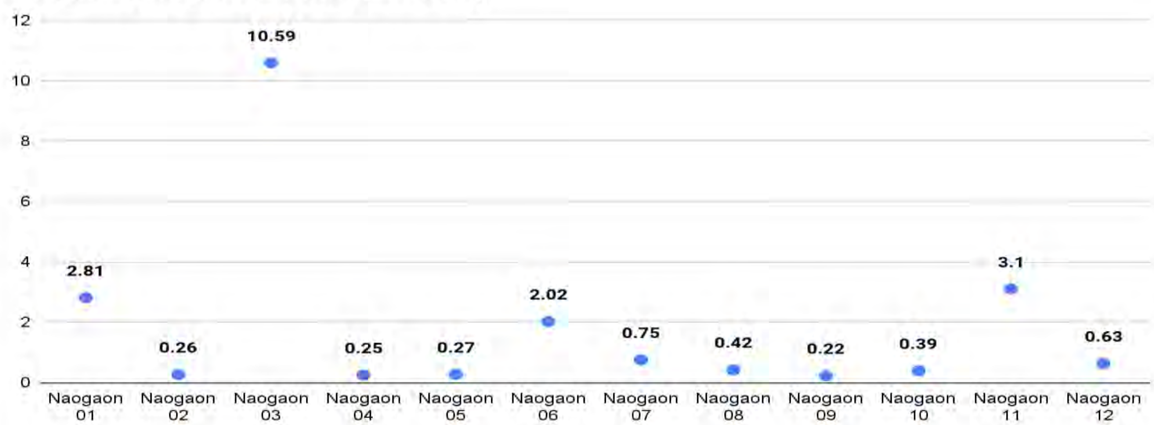


The radio frequency (RF) emissions from both cell towers and HVTL towers are compared and visualized through the four graphs. Data was collected from around 26 towers from this city which was a lot compared to the other cities covered in this research. 24 of them were cell towers and the rest 2 were HVTL. 3 of the 24 cell towers were found to have Rf values less than the safety range of below 45. The values were 0.42, 23.8, and 39.85 from towers 18, 21, and 22 respectively. The highest radio frequency was found from tower 24 which was around 5422 and was a HVTL tower. Towers 23 and 26 were also not far away with 3009.3 and 2163 respectively. The bar graph shows the RF strength for both types of towers, making it easy to compare the emissions. The line graph tracks changes in RF exposure over time, highlighting any patterns or spikes. In the column graph, the average RF values are contrasted with established safety standards, quickly revealing if any of the measured values exceed acceptable limits. Lastly, the scatter graph visualizes the relationship between RF and factors such as location or tower type and in this case, tower type.

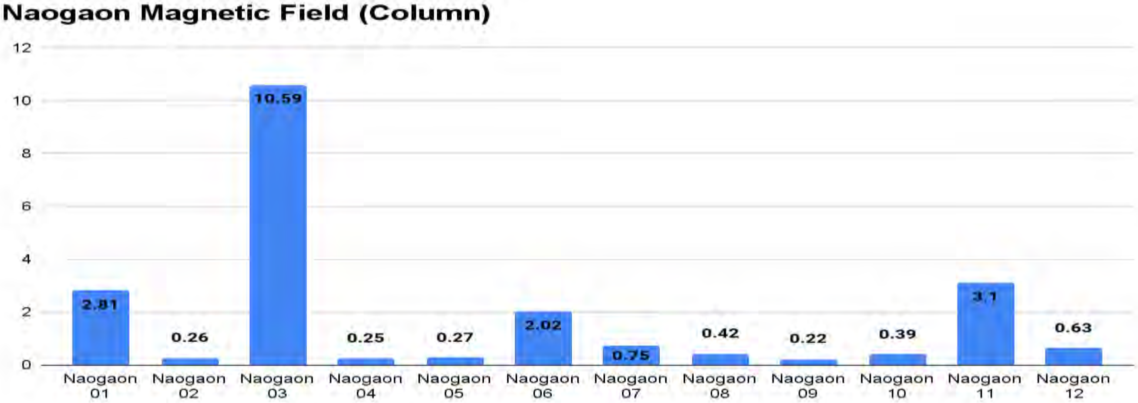
Naogaon Magnetic Field (Line)

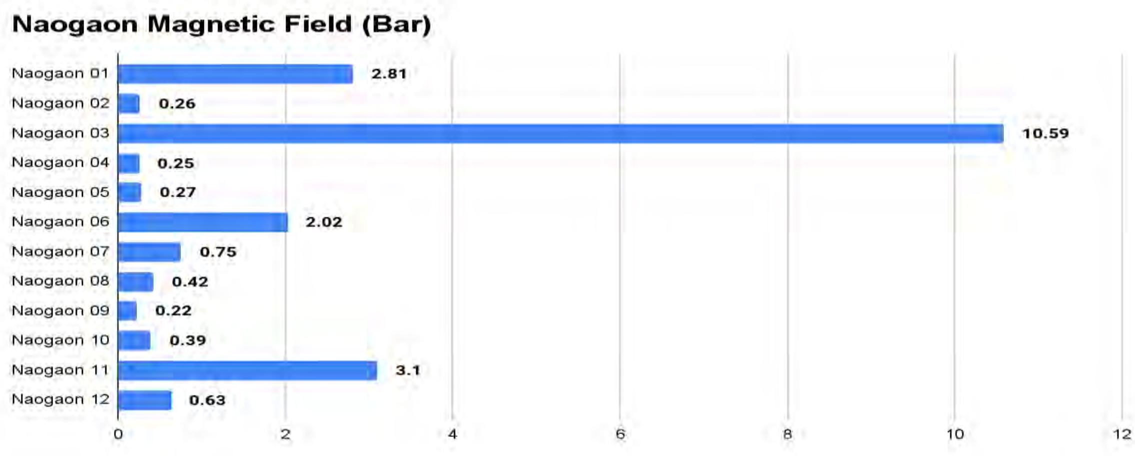


Naogaon Magnetic Field (Scatter)

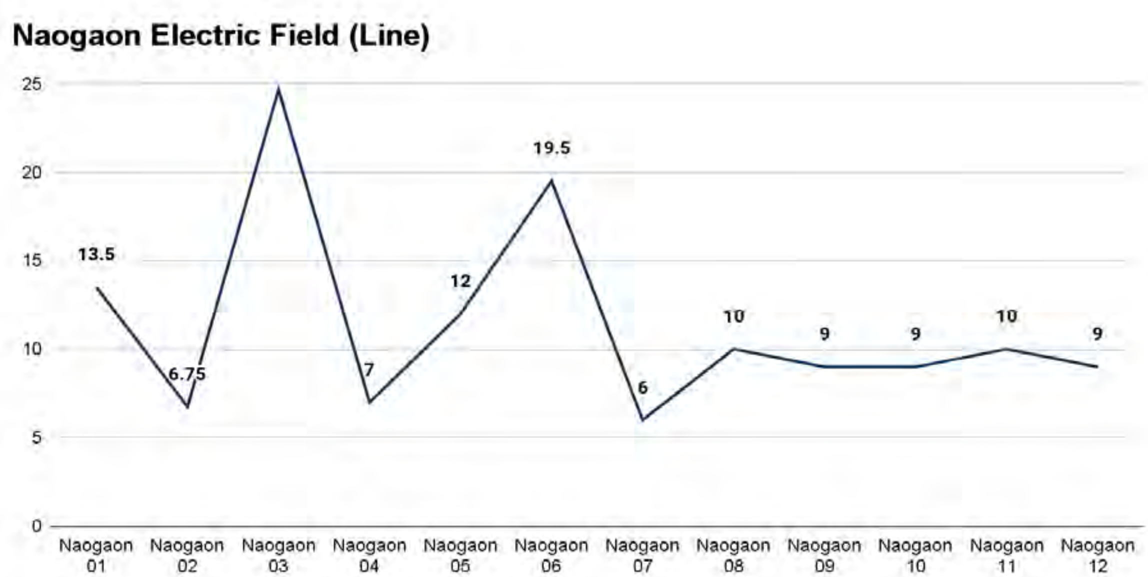


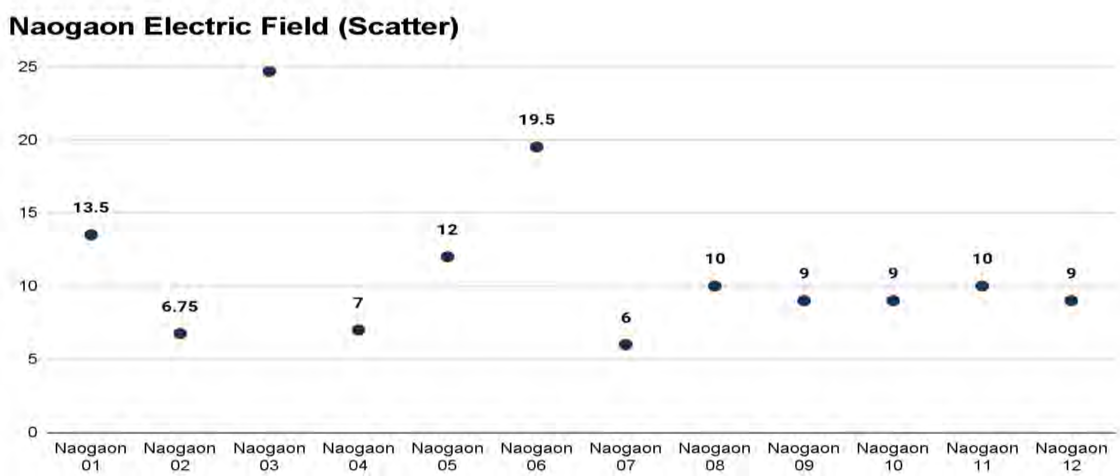
Naogaon Magnetic Field (Column)

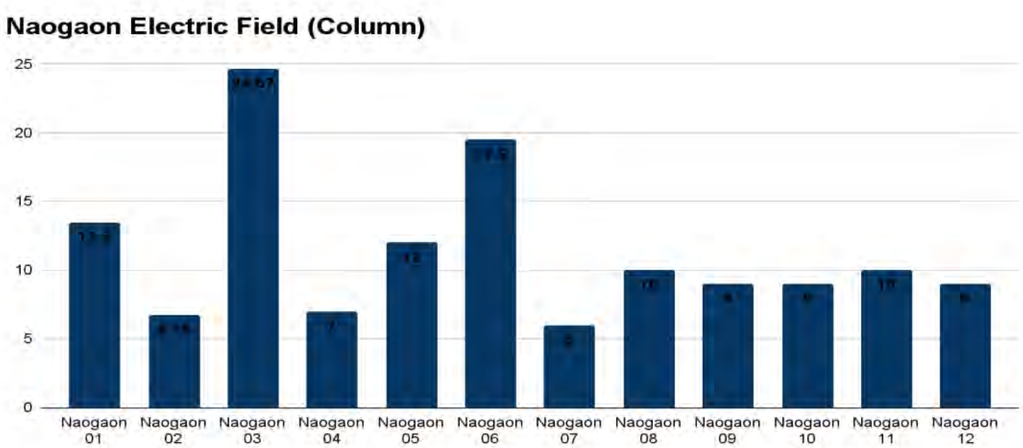


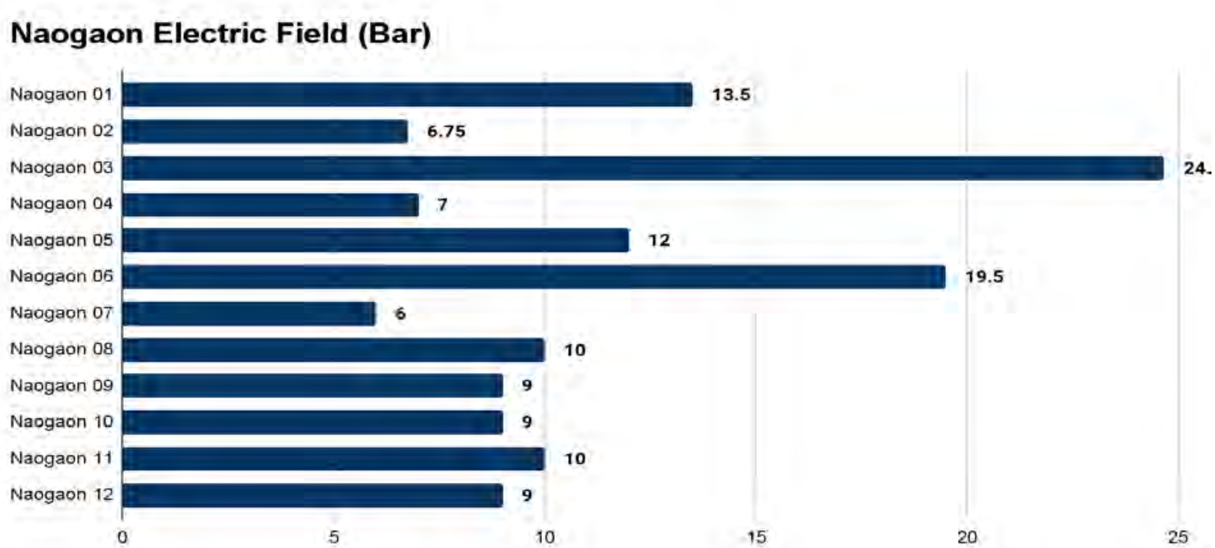


The data for magnetic field intensities from cell towers and HVTL towers is presented through a combination of bar, line, column, and scatter graphs. In Naogaon, the 7 cell towers are emitting magnetic fields above the standard safety limit of 0.1 mG, with Towers 01, 03, and 11 emitting the highest levels of radiation. In contrast, all 5 HVTL towers are within the safe range.

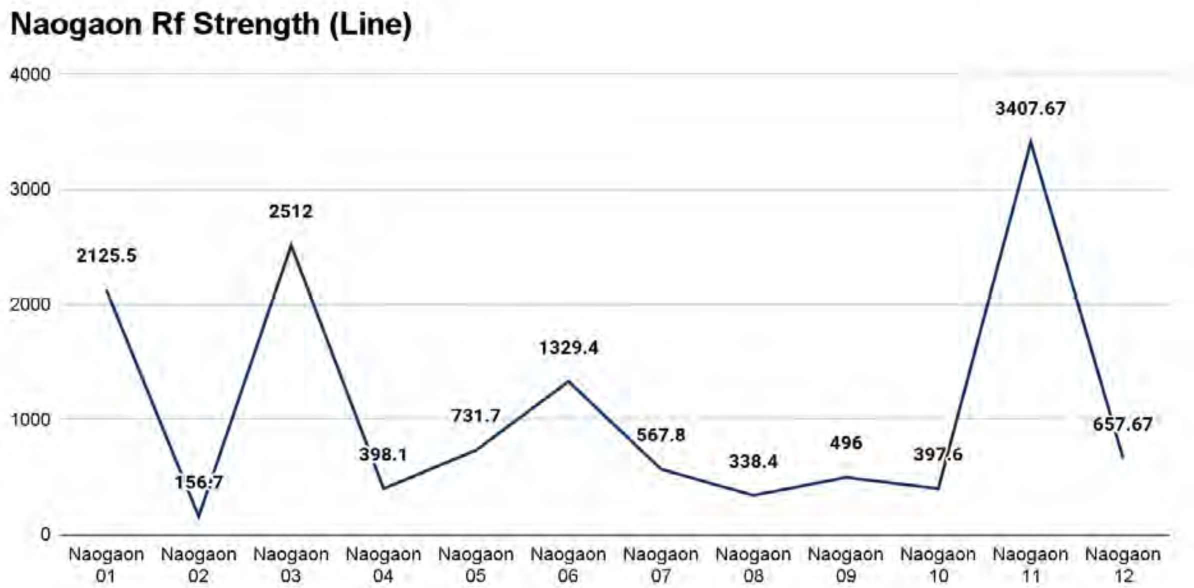


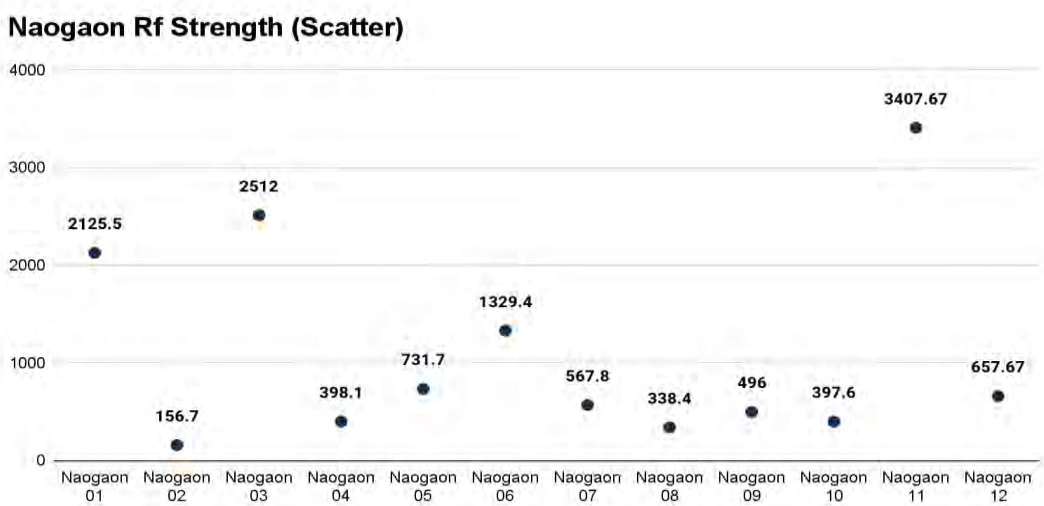

Naogaon Electric Field (Scatter)
25
20
15
10
5
0
13.5
6.75
12
19.5
7
6
10
9
9
10
9
Naogaon 01
Naogaon 02
Naogaon 03
Naogaon 04
Naogaon 05
Naogaon 06
Naogaon 07
Naogaon 08
Naogaon 09
Naogaon 10
Naogaon 11
Naogaon 12

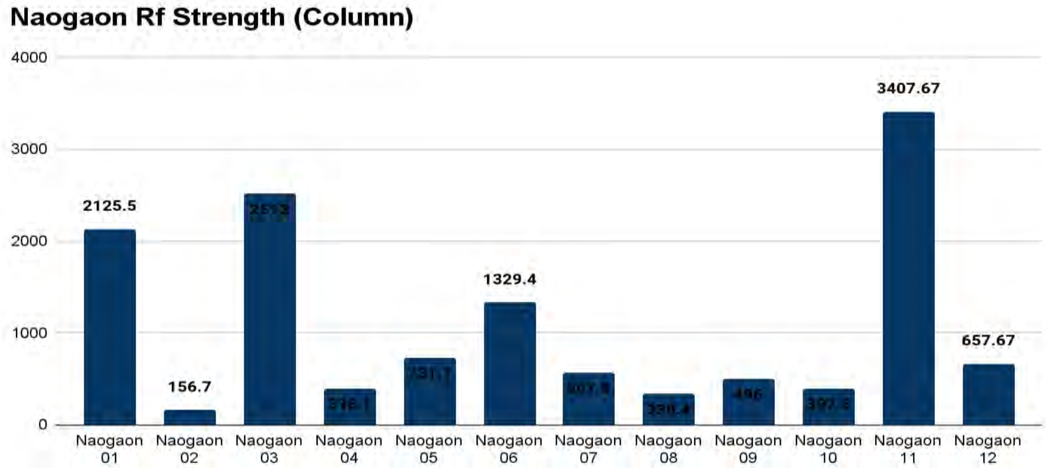

Naogaon Electric Field (Column)
25
20
15
10
5
0
Naogaon 01
Naogaon 02
Naogaon 03
Naogaon 04
Naogaon 05
Naogaon 06
Naogaon 07
Naogaon 08
Naogaon 09
Naogaon 10
Naogaon 11
Naogaon 12

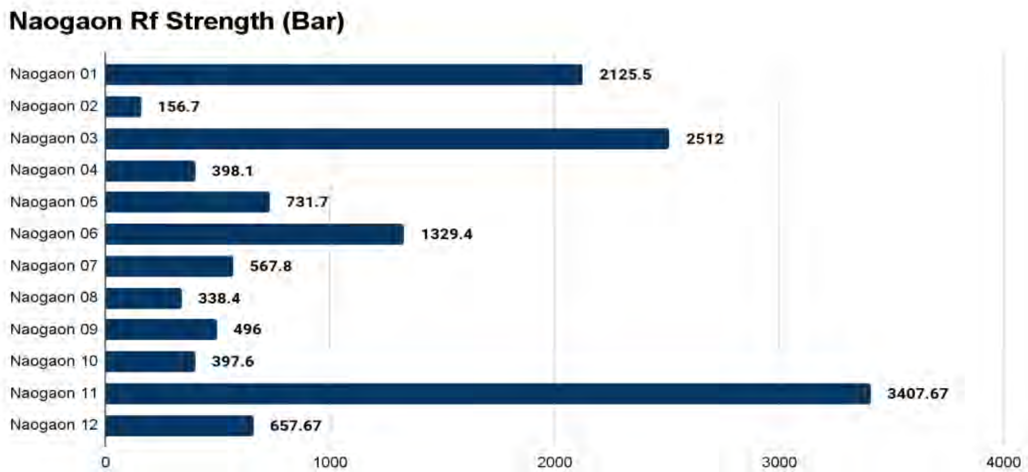

Naogaon Electric Field (Bar)
Naogaon 01
13.5
Naogaon 02
6.75
Naogaon 03
24.
Naogaon 04
7
Naogaon 05
12
Naogaon 06
19.5
Naogaon 07
6
Naogaon 08
10
Naogaon 09
9
Naogaon 10
9
Naogaon 11
10
Naogaon 12
9
0
5
10
15
20
25

The electric field data is also displayed using a combination of graphs to enhance comparison and trend analysis. For the electric field, again all of the 7 cell towers were found to be crossing the safety level. Towers 2,7 and 6 were the closest to the safety range with 6.75 v/m, 7, and 6 v/m respectively. The rest of the towers are way past 10 v/m with 24.67 V/m being the highest electric field emitted by tower 3. However, for HVTL, all of the 5 towers were found to be under the optimal range of 1 kV/m to 10 kV/m.

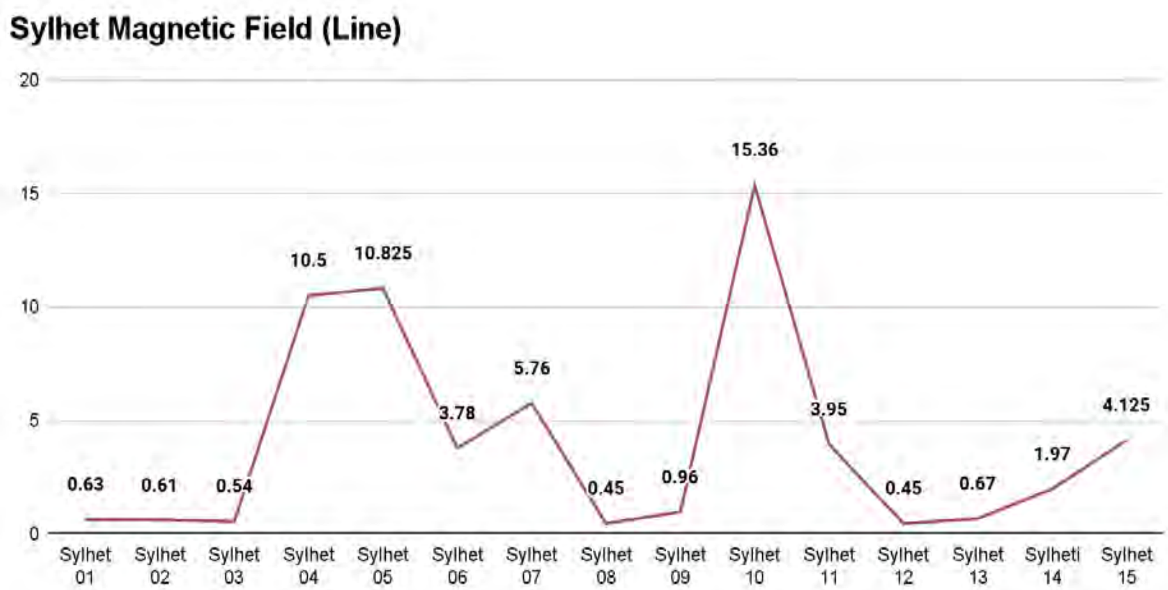


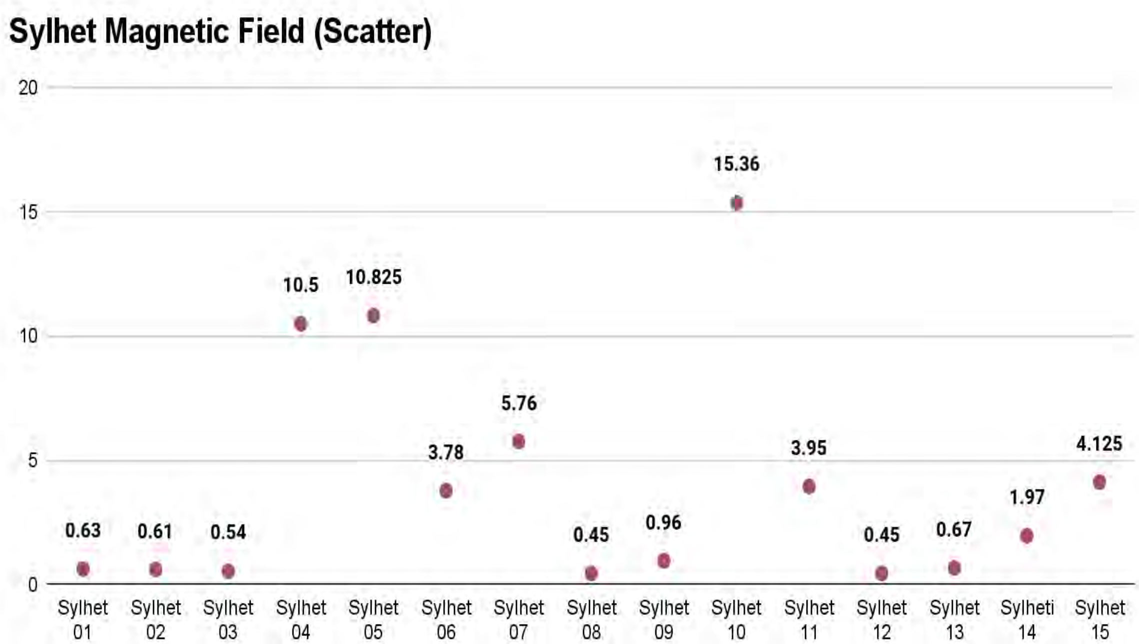


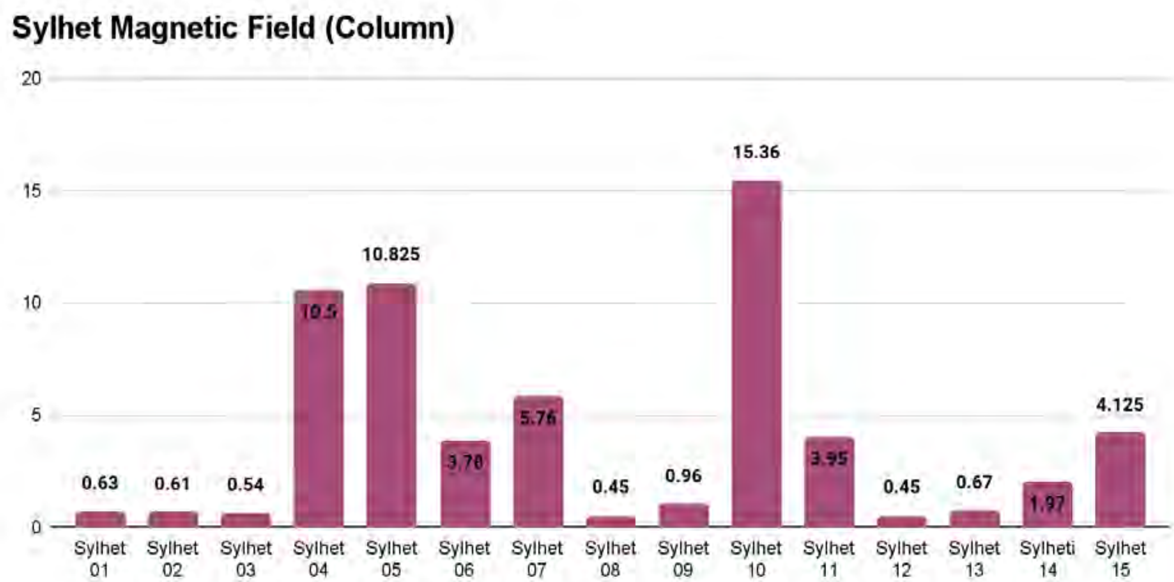


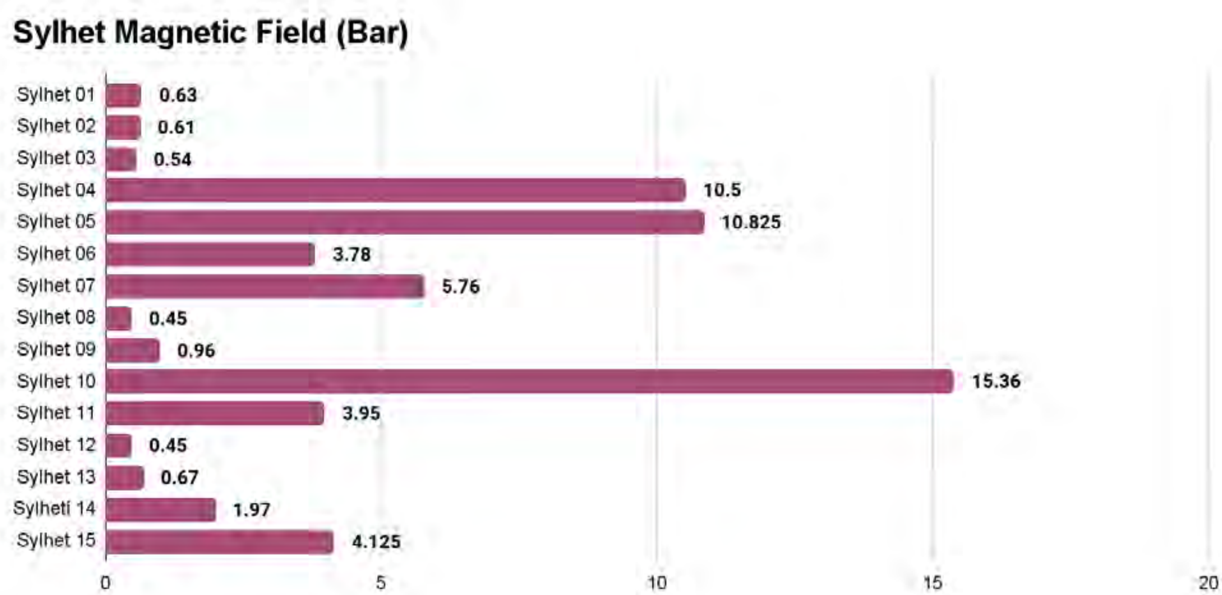


In terms of Rf strength, in the district of Naogaon, there was no tower with emitted Rf strength that was below 45 µW/m^2 for the cell towers. Each of the cell towers emitted radio frequency way above the safety range. Most of the towers emitted radio frequency that was in the 100s and 3 of the towers crossed that margin and went to the 1000s with the emitted frequencies being 2125.5 µW/m^2 , 2912 µW/m^2 and 3407.67 µW/m^2 respectively. For 5 HVTL towers, it was a different case, as all of them were within the optimum range. The radio frequency (RF) emissions from both cell towers and HVTL towers were then compared and visualized through the four graphs.

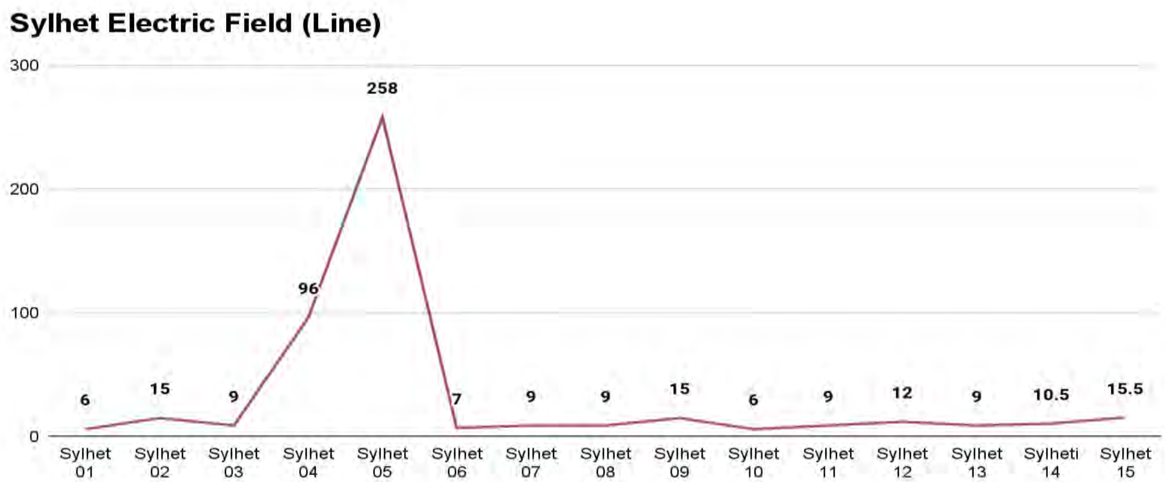

Sylhet Magnetic Field (Line)
20
15
10
5
0
15.36
10.5
10.825
5.76
3.78
3.95
4.125
1.97
0.63
0.61
0.54
0.45
0.96
0.45
0.67
Sylhet 01
Sylhet 02
Sylhet 03
Sylhet 04
Sylhet 05
Sylhet 06
Sylhet 07
Sylhet 08
Sylhet 09
Sylhet 10
Sylhet 11
Sylhet 12
Sylhet 13
Sylheti 14
Sylhet 15

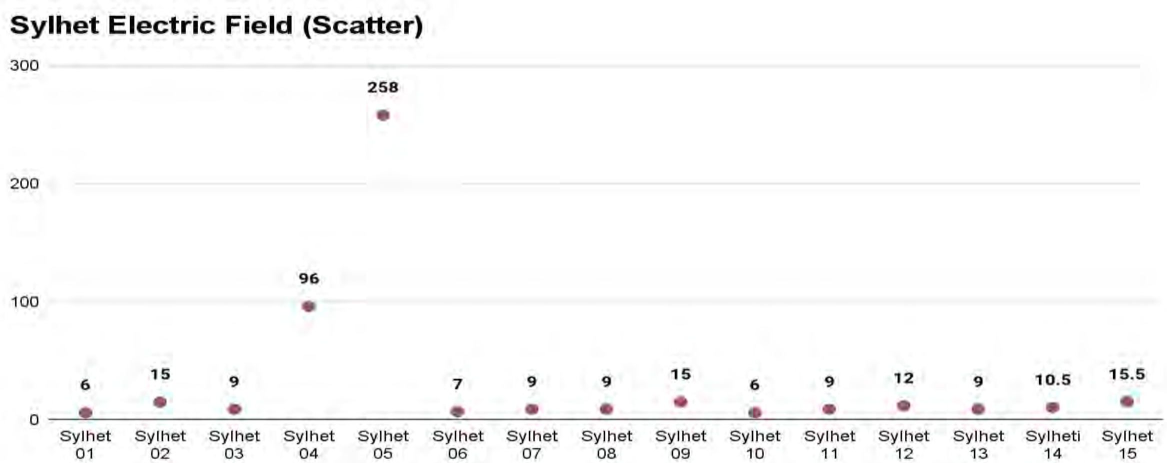

Sylhet Magnetic Field (Scatter)
20
15
10
5
0
15.36
10.5
10.825
5.76
3.78
3.95
4.125
1.97
0.63
0.61
0.54
0.45
0.96
0.45
0.67
Sylhet 01
Sylhet 02
Sylhet 03
Sylhet 04
Sylhet 05
Sylhet 06
Sylhet 07
Sylhet 08
Sylhet 09
Sylhet 10
Sylhet 11
Sylhet 12
Sylhet 13
Sylheti 14
Sylhet 15

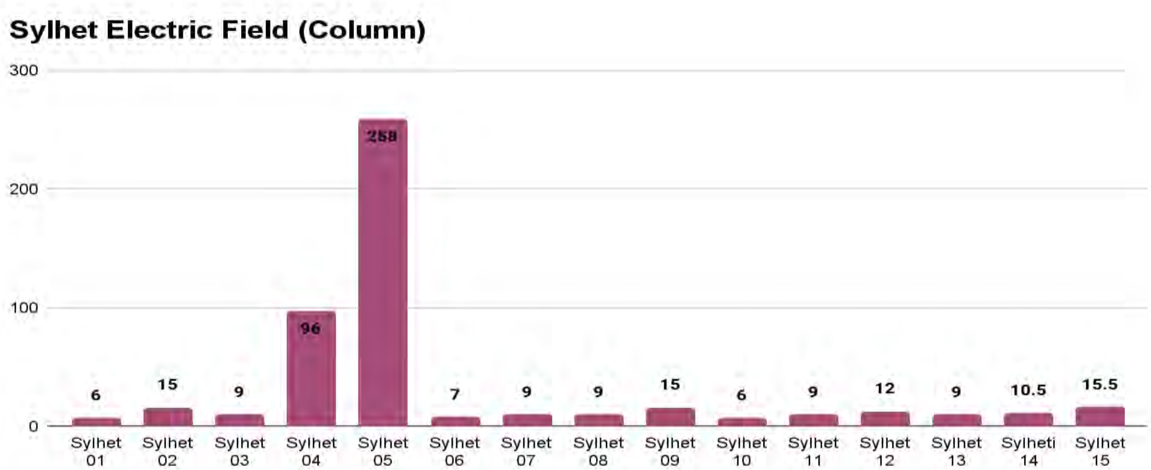


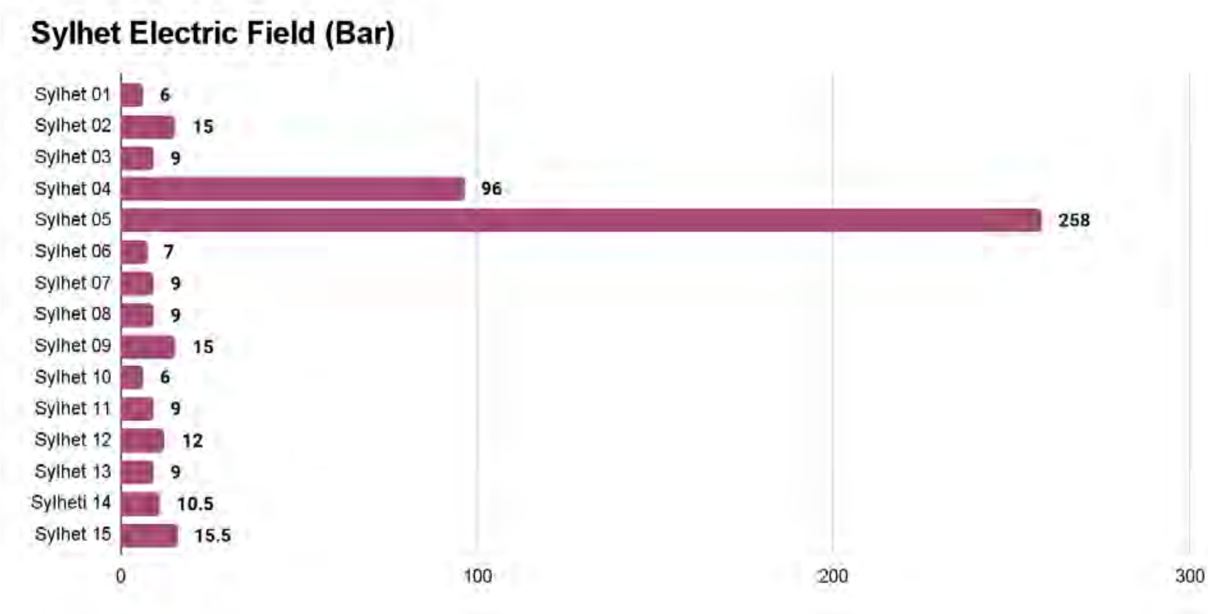


The data for magnetic field intensities from cell towers and HVTL towers is presented through a combination of bar, line, column, and scatter graphs. In terms of the magnetic field, all of the 11 cell towers crossed the safety level of 0.1 mG with towers 4,5 and 10 having the highest emission of 10.5, 10.8, and 15.36 mG respectively. The rest of the HVTL towers were within the marginal line of **1 milligauss (mG) to 200 milligauss (mG).**

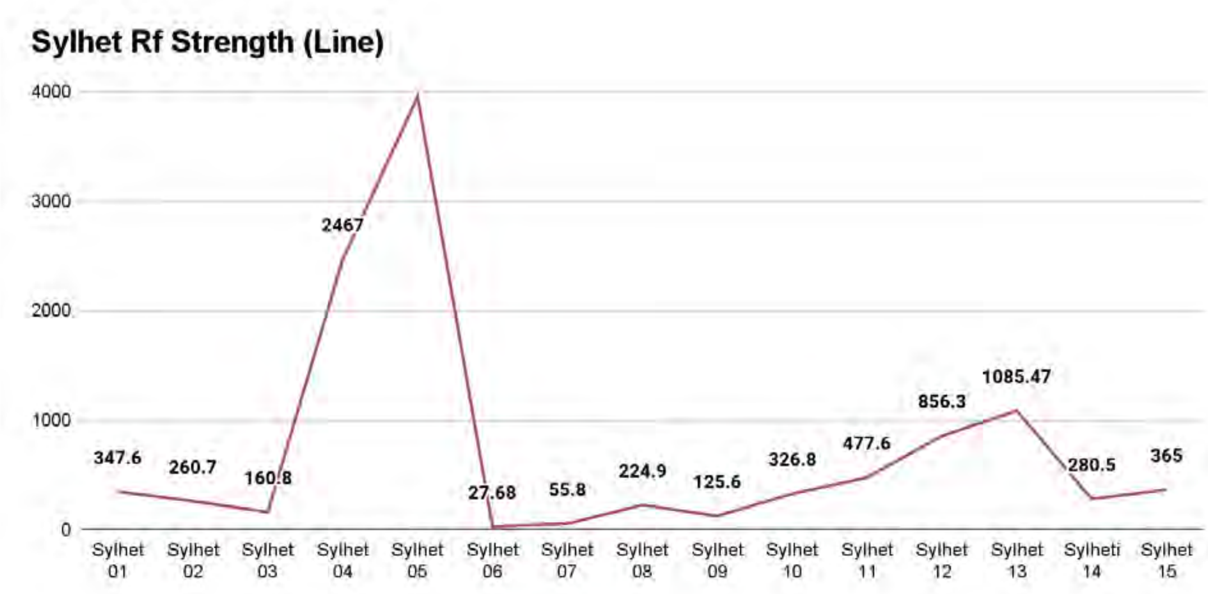

Sylhet Electric Field (Line)
300
200
100
0
258
96
6
15
9
7
9
9
15
6
9
12
9
10.5
15.5
Sylhet 01
Sylhet 02
Sylhet 03
Sylhet 04
Sylhet 05
Sylhet 06
Sylhet 07
Sylhet 08
Sylhet 09
Sylhet 10
Sylhet 11
Sylhet 12
Sylhet 13
Sylheti 14
Sylhet 15

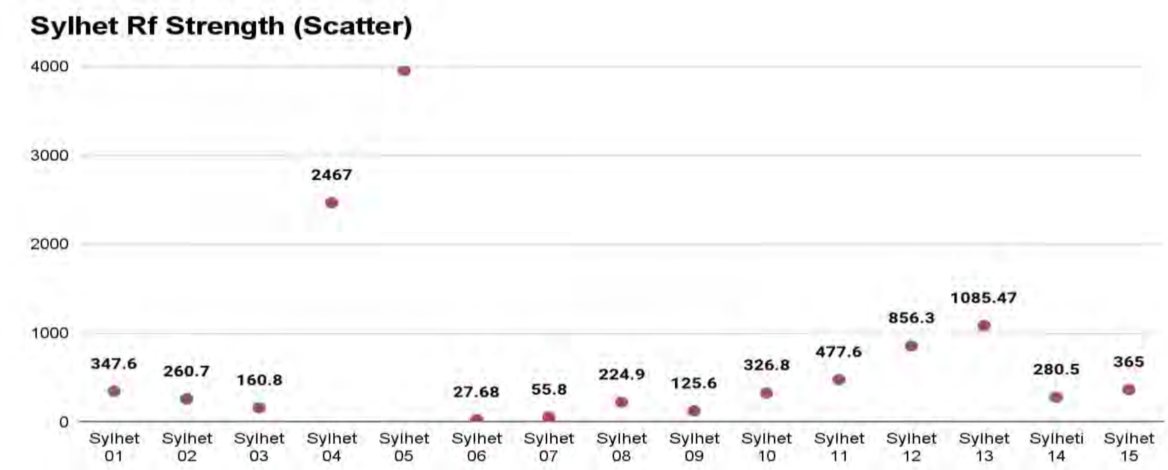

Sylhet Electric Field (Scatter)
300
200
100
0
258
96
6
15
9
7
9
9
15
6
9
12
9
10.5
15.5
Sylhet 01
Sylhet 02
Sylhet 03
Sylhet 04
Sylhet 05
Sylhet 06
Sylhet 07
Sylhet 08
Sylhet 09
Sylhet 10
Sylhet 11
Sylhet 12
Sylhet 13
Sylheti 14
Sylhet 15

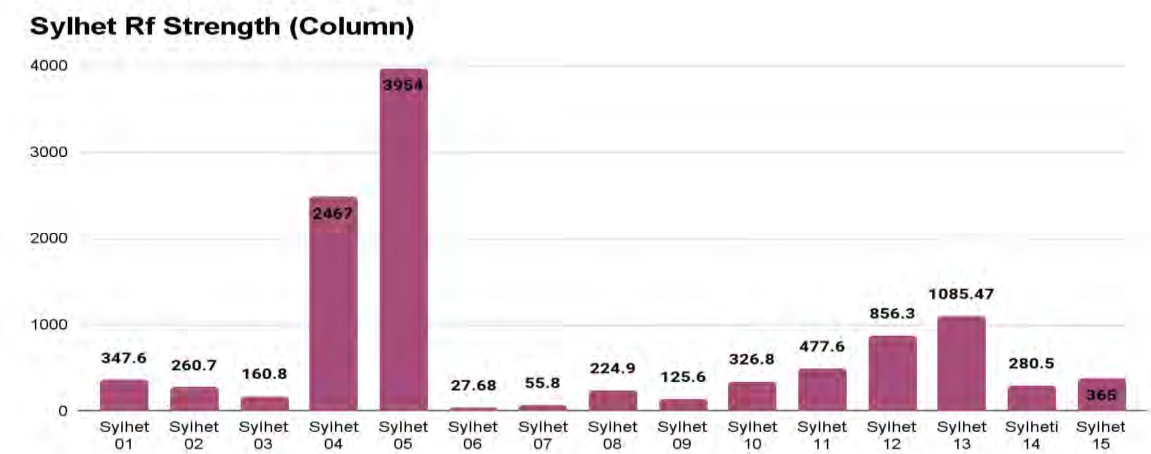

Sylhet Electric Field (Column)
300
200
100
0
258
96
6
15
9
7
9
9
15
6
9
12
9
10.5
15.5
Sylhet 01
Sylhet 02
Sylhet 03
Sylhet 04
Sylhet 05
Sylhet 06
Sylhet 07
Sylhet 08
Sylhet 09
Sylhet 10
Sylhet 11
Sylhet 12
Sylhet 13
Sylheti 14
Sylhet 15

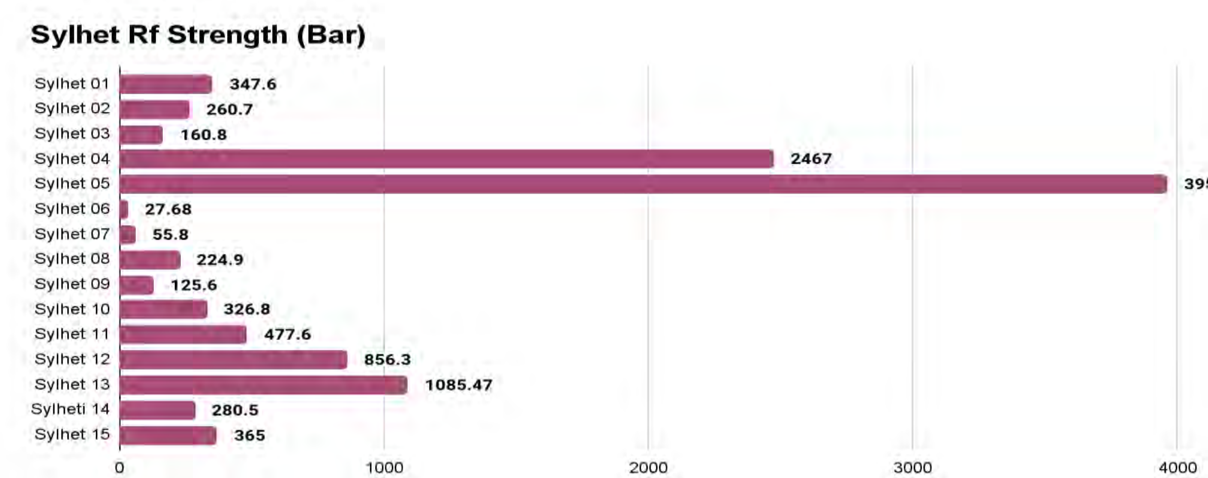


The electric field data for cell towers and HVTL towers in Sylhet is analyzed using a combination of graphs to facilitate comparison and identify trends The safe levels for Electric field emitted by cell towers is between 0.5 V/m and 5 V/m. However, all of the cell towers are emitting NIR that exceeds safe levels, averaging at a value significantly higher than the highest allowed safe value of 5 V/m. Towers 01 and 10 are closer to the safe levels but are still emitting radiation at a dangerous level.

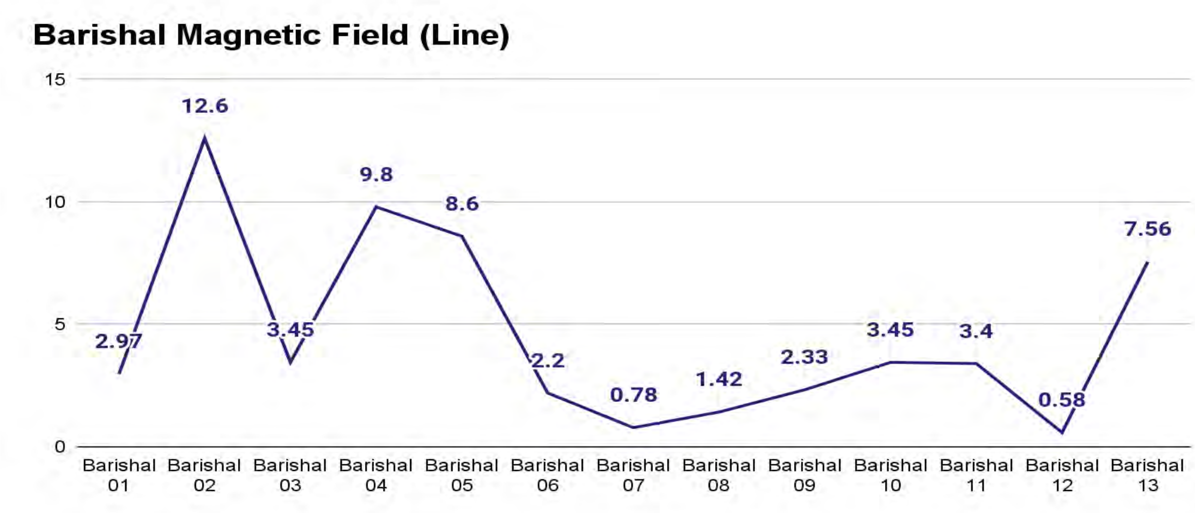


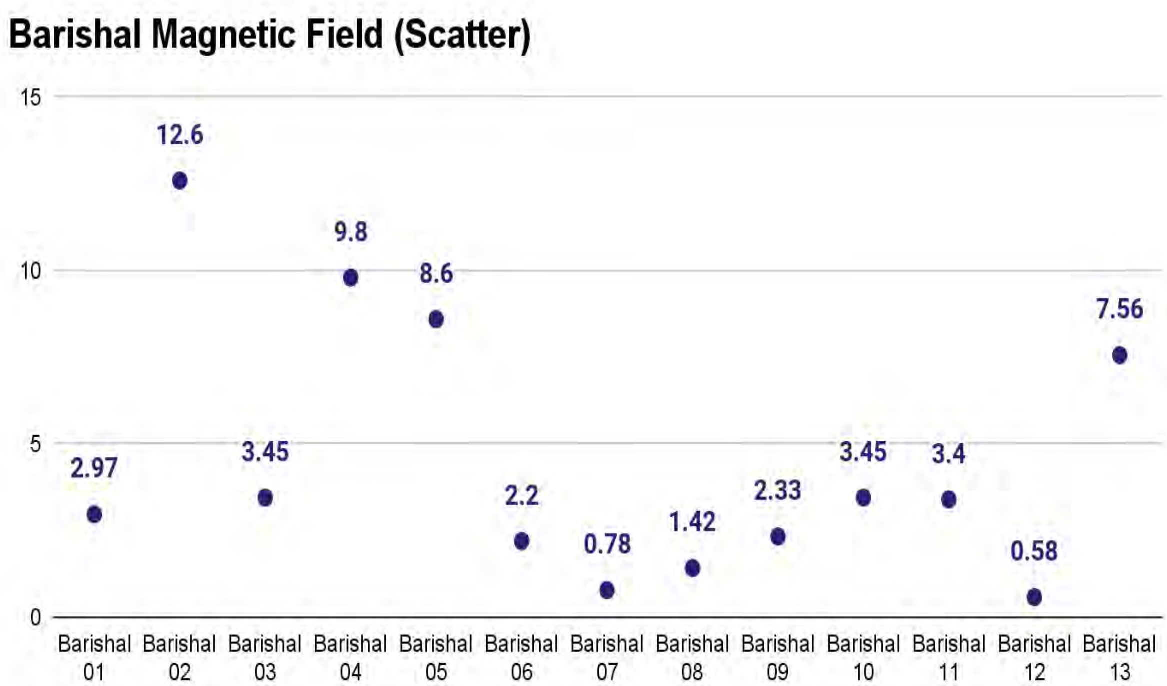


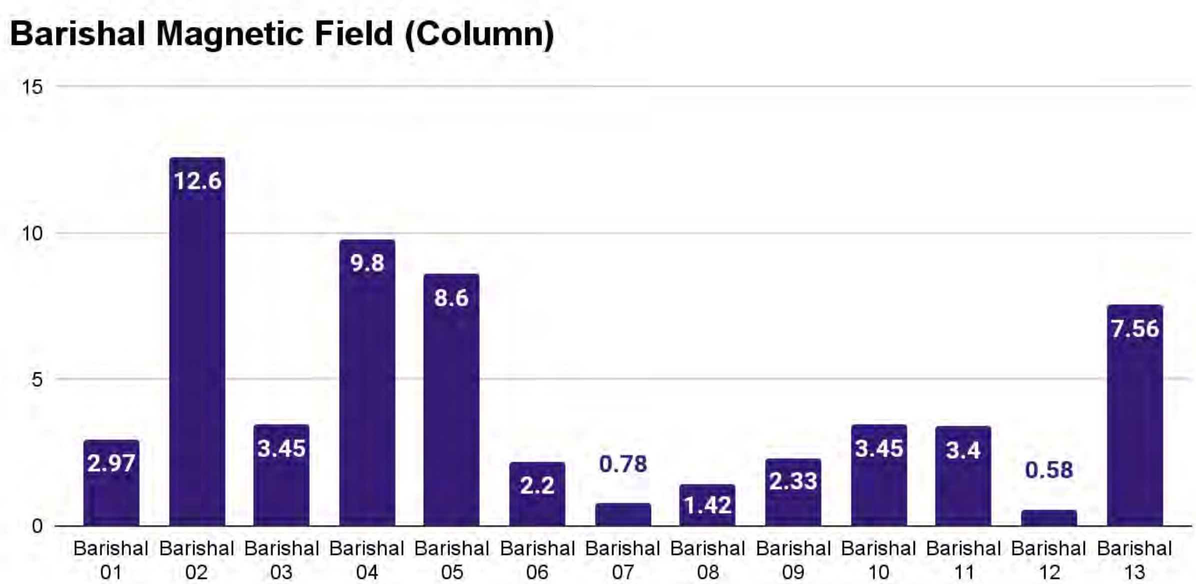


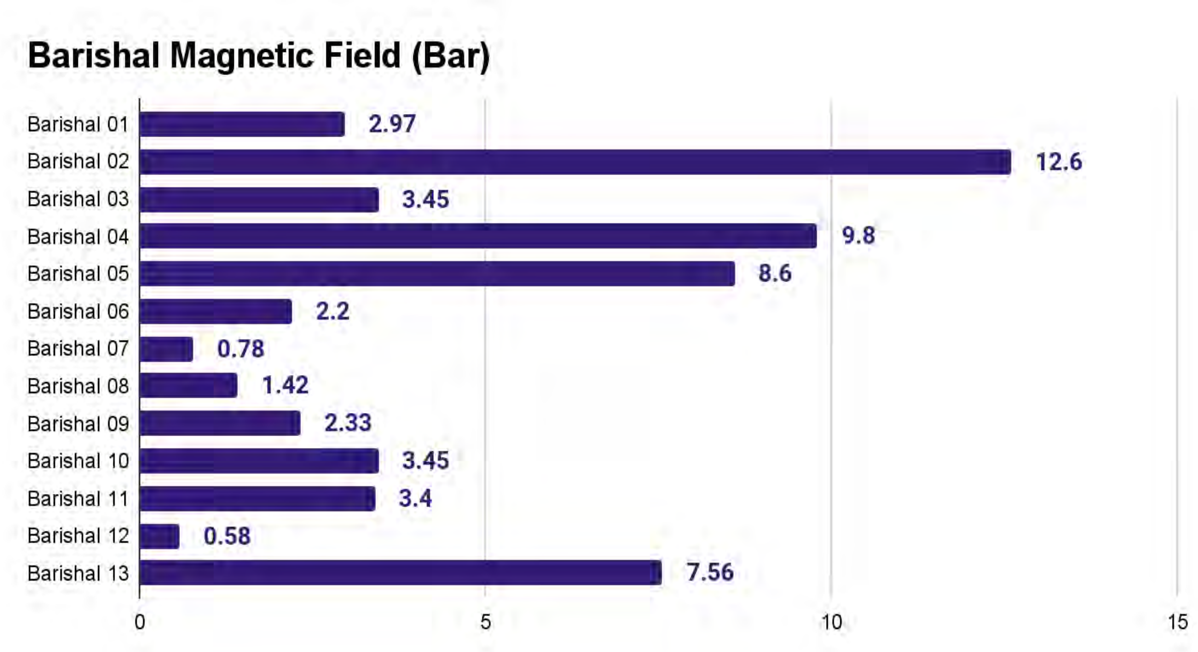


Surprisingly among the 11 cell towers that were measured, only one of them was found to have an Rf strength of 27.68 µW/m^2 which was below the safety level of 45 µW/m^2. The nearest one was 55.8 µW/m^2, still above the safety range. The rest of the 13 towers were way past the safety threshold level, some were found to be in 100 range and 3 of the towers were in 1000 range. Tower 4 and 5 had the highest Rf emission with 2467 µW/m^2 and 3954 µW/m^2 respectively which fell in the four HVTL that were found in the area The radio frequency (RF) emissions from both cell towers and HVTL towers were compared using bar, line, column, and scatter graphs. These visualizations make it easy to identify differences, track changes over time, and assess compliance with safety standards



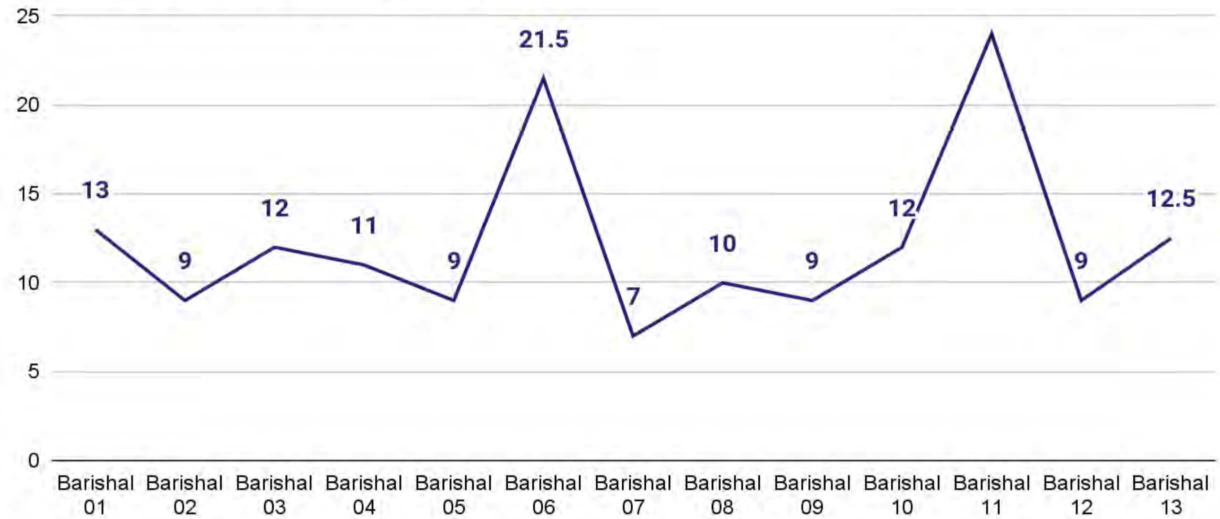

Barishal Magnetic Field (Scatter)
15
10
5
0
12.6
9.8
8.6
7.56
2.97
3.45
2.2
0.78
1.42
2.33
3.45
3.4
0.58
Barishal 01
Barishal 02
Barishal 03
Barishal 04
Barishal 05
Barishal 06
Barishal 07
Barishal 08
Barishal 09
Barishal 10
Barishal 11
Barishal 12
Barishal 13


Barishal Magnetic Field (Column)
15
10
5
0
12.6
9.8
8.6
7.56
2.97
3.45
2.2
0.78
1.42
2.33
3.45
3.4
0.58
Barishal 01
Barishal 02
Barishal 03
Barishal 04
Barishal 05
Barishal 06
Barishal 07
Barishal 08
Barishal 09
Barishal 10
Barishal 11
Barishal 12
Barishal 13

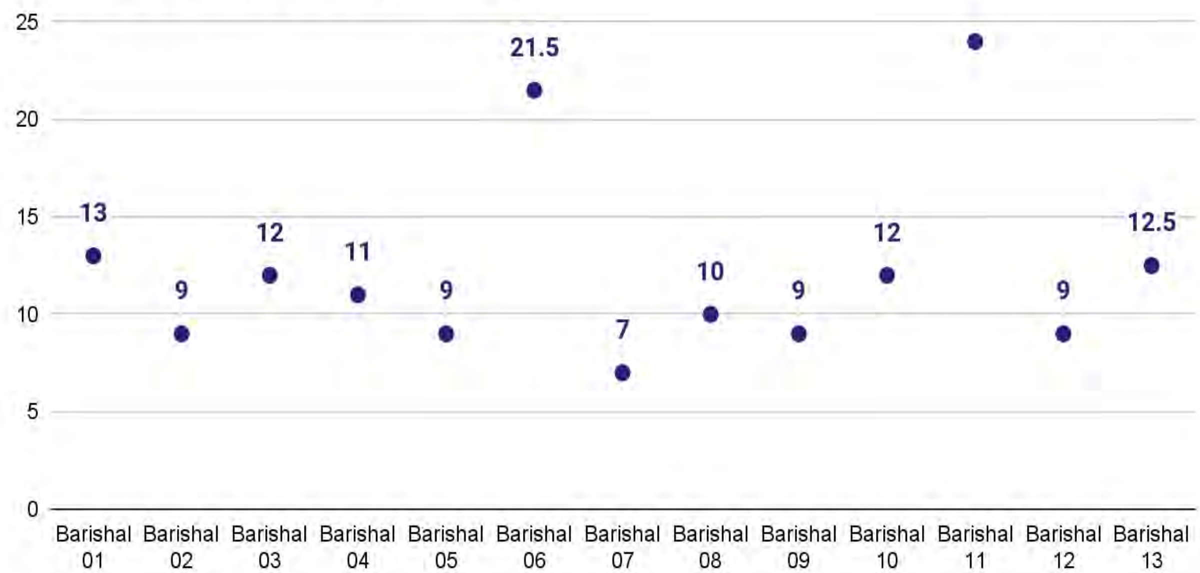


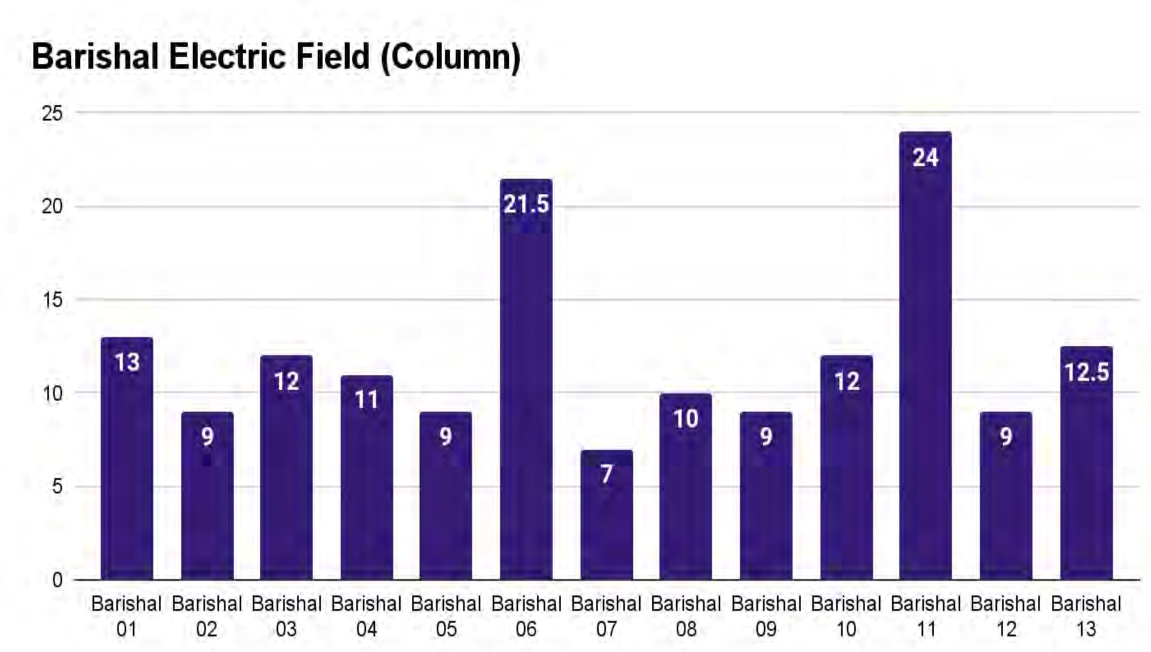
The magnetic field intensity data from cell towers and HVTL towers in Barishal has been analyzed through a series of bar, line, column, and scatter graphs. The bar graph provides a clear distinction between the emissions from cell towers and HVTL towers, emphasizing which type produces higher magnetic field levels. The line graph tracks the fluctuations in magnetic field strength over time, helping to observe any temporal patterns. Using the column graph, we compare the average magnetic field values against standard safety limits, offering a straightforward way to evaluate compliance. Lastly, the scatter graph explores potential correlations between magnetic field intensities across different locations. The situation is also in terms of Magnetic field as all of the towers emitting Magnetic fields exceed the safe value of 0.1 mG. All the towers, starting from Tower 01, up until Tower 13, are emitting dangerous levels of Magnetic fields.

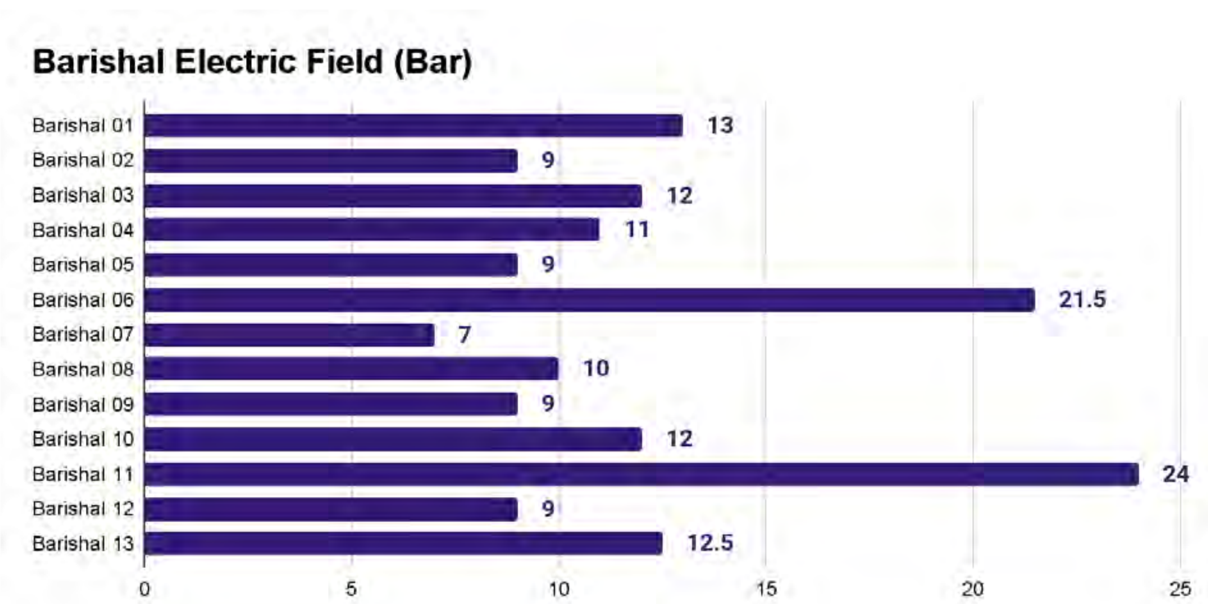
Barishal Electric Field (Line)



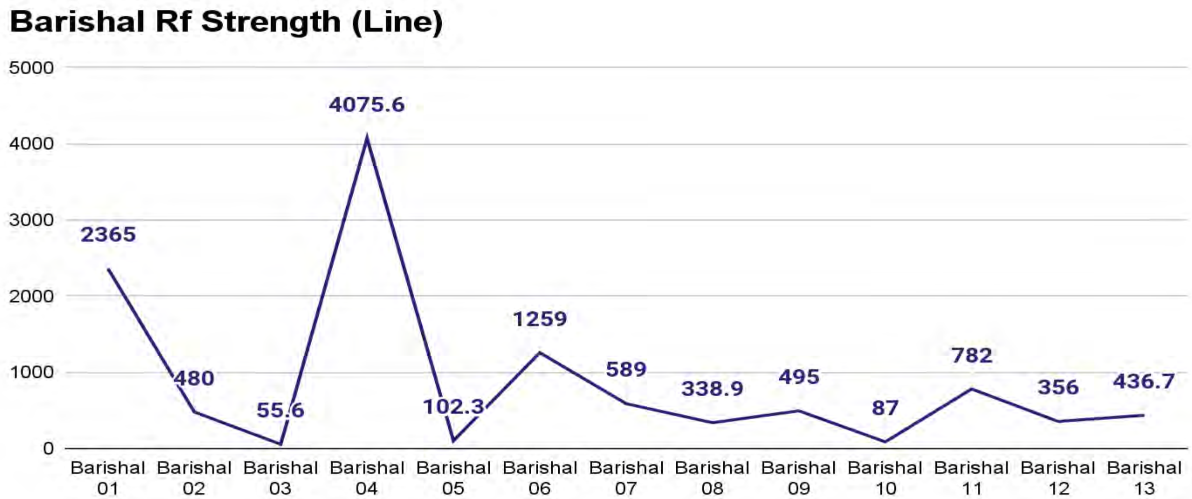
Barishal Electric Field (Scatter)

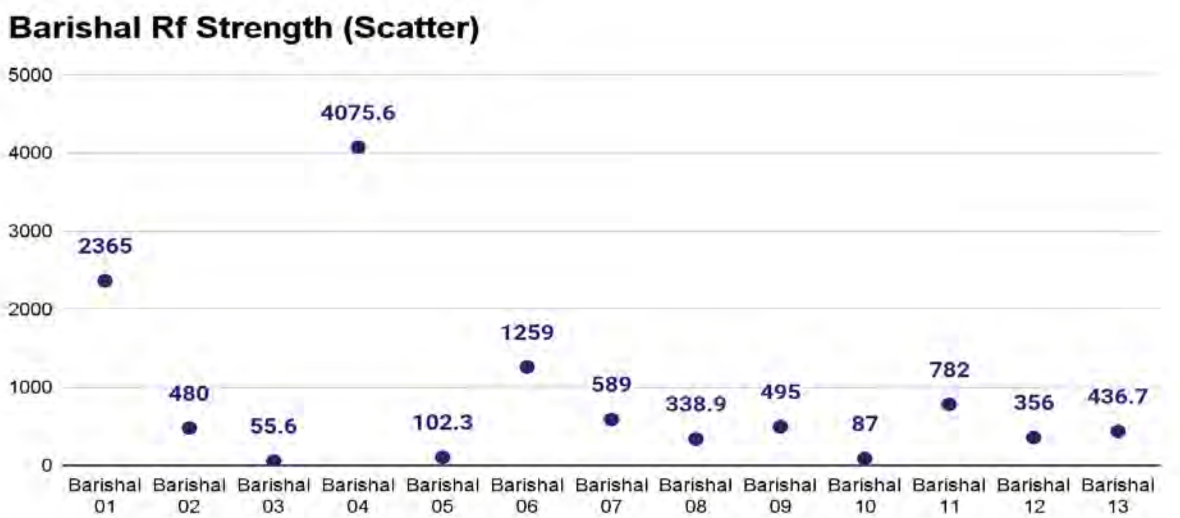






All of the cell towers were found to exit the safety level in terms of the electric field which is between 0.5 V/m and 5 V/m. Towers 6 and 7 with 21.5 V/m and 24.5 V/m respectively being the highest of the 13 towers that were measured. Moreover, all HVTL towers were in the range of electric field emission having the optimal range of 1 kV/m to 10 kV/m. The emissions from both cell towers and HVTL towers were compared using bar, line, column, and scatter graphs to successfully analyze them.


Barishal Rf Strength (Line)
5000
4000
3000
2000
1000
0
4075.6
2365
1259
782
589
495
480
436.7
356
338.9
102.3
87
55.6
Barishal 01
Barishal 02
Barishal 03
Barishal 04
Barishal 05
Barishal 06
Barishal 07
Barishal 08
Barishal 09
Barishal 10
Barishal 11
Barishal 12
Barishal 13


Barishal Rf Strength (Scatter)
5000
4000
3000
2000
1000
0
4075.6
2365
1259
782
589
495
480
436.7
356
338.9
102.3
87
55.6
Barishal 01
Barishal 02
Barishal 03
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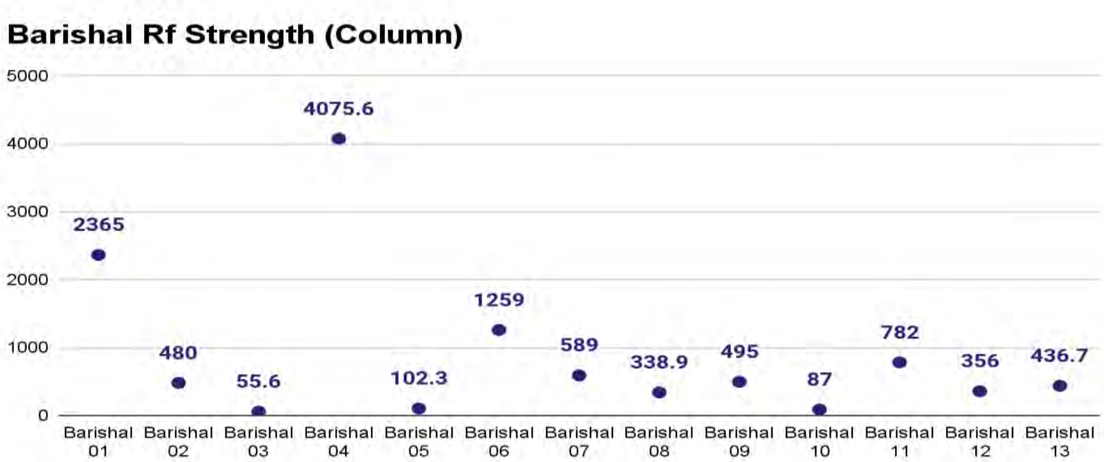
Barishal 06
Barishal 07
Barishal 08
Barishal 09
Barishal 10
Barishal 11
Barishal 12
Barishal 13


Barishal Rf Strength (Column)
5000
4000
3000
2000
1000
0
4075.6
2365
1259
782
589
495
480
436.7
356
338.9
102.3
87
55.6
Barishal 01
Barishal 02
Barishal 03
Barishal 04
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Barishal 06
Barishal 07
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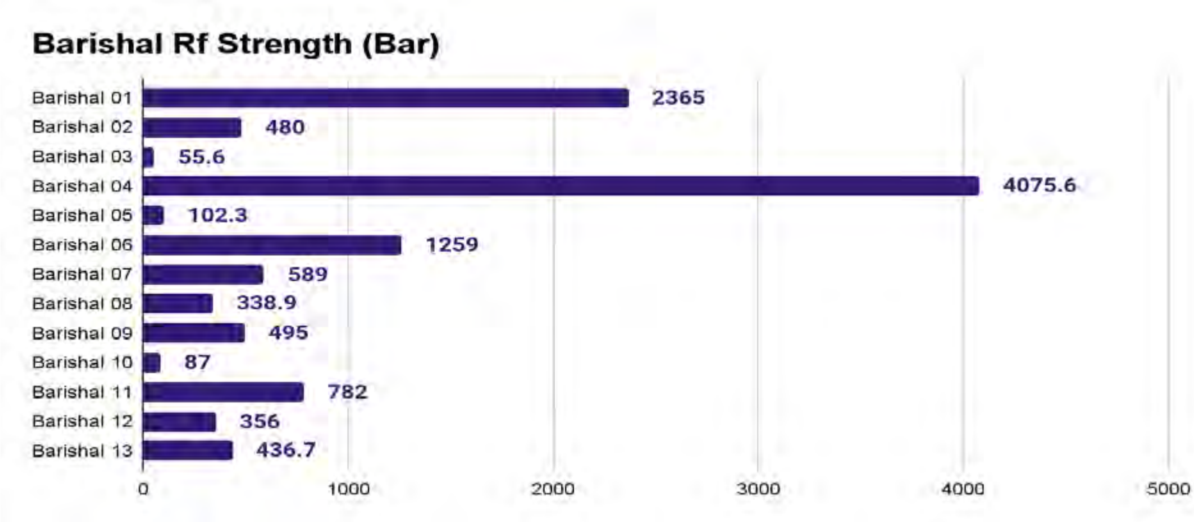
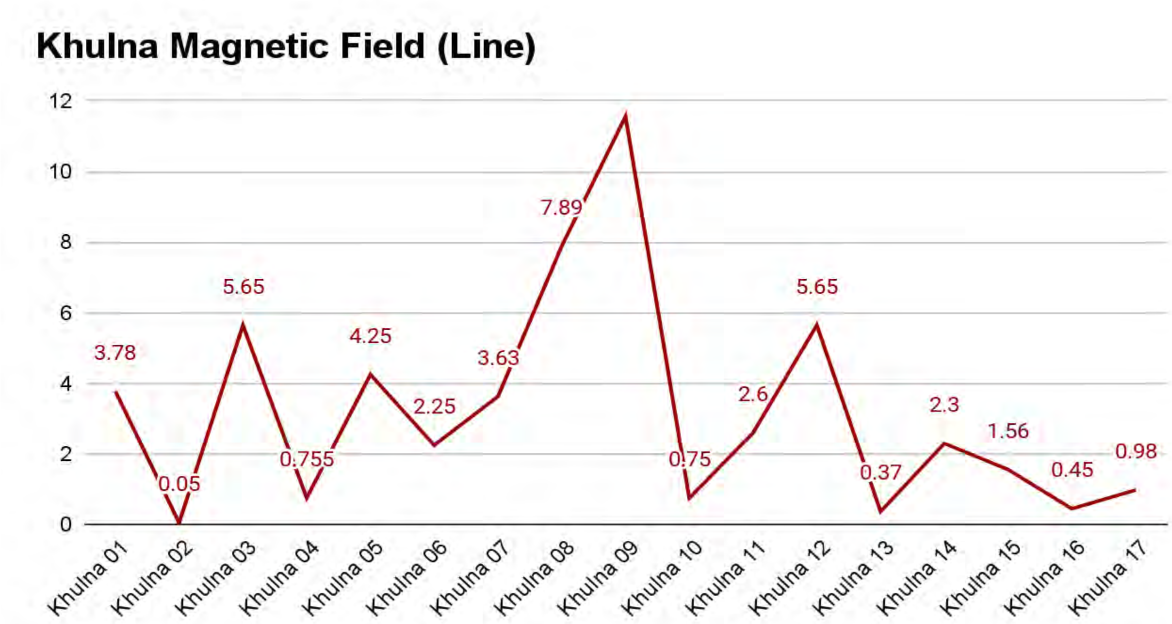
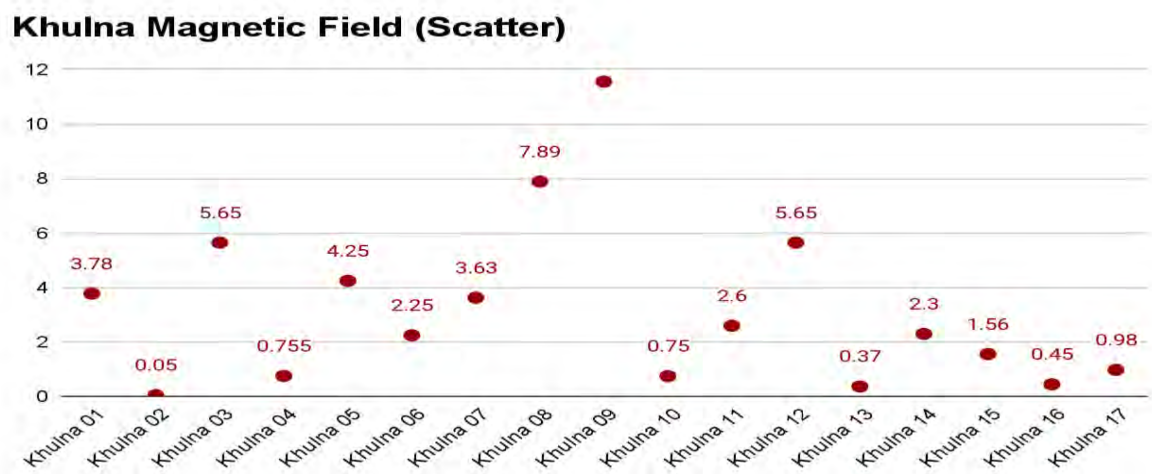
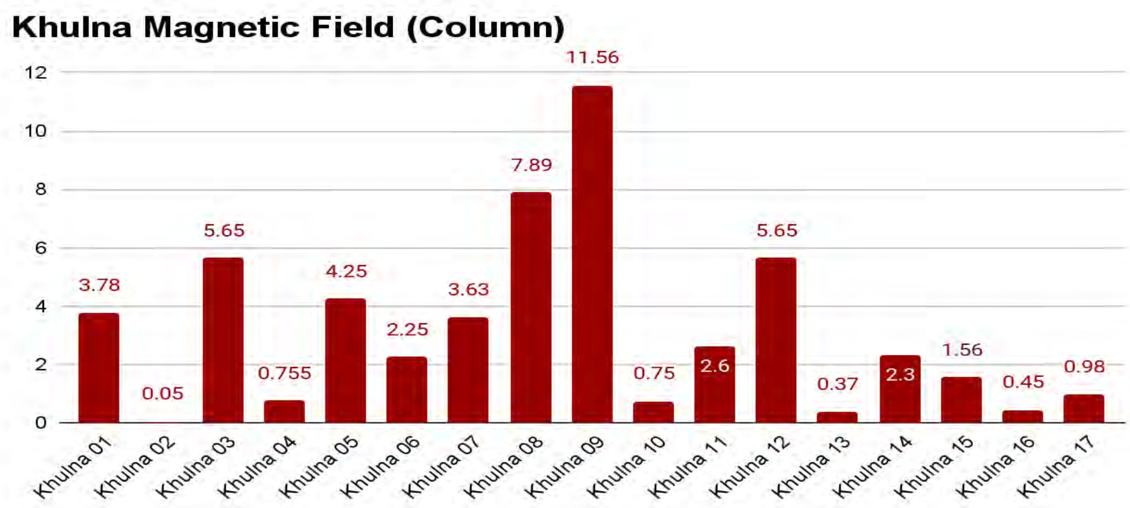
Barishal 09
Barishal 10
Barishal 11
Barishal 12
Barishal 13

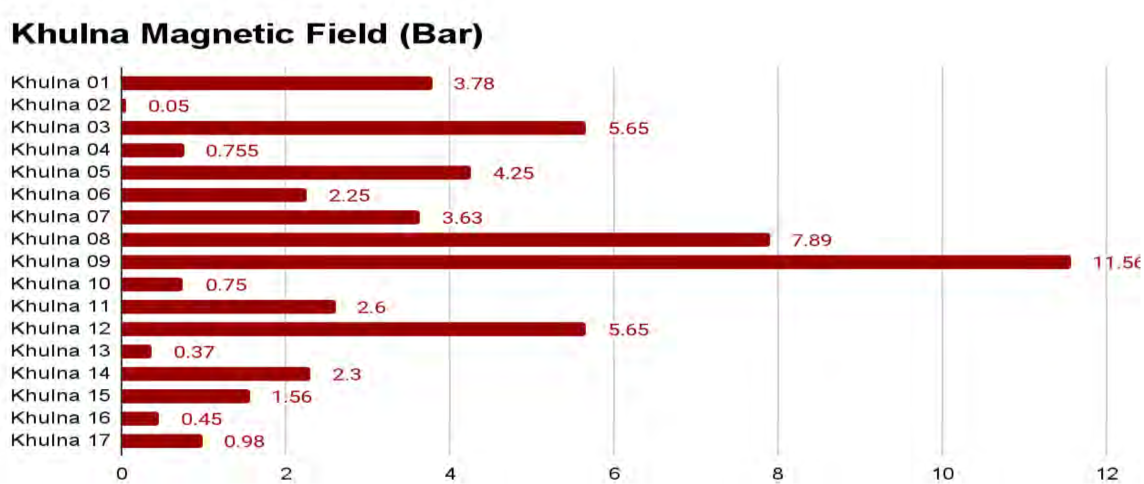


The radio frequency (RF) emissions from both cell towers and HVTL towers were compared using bar, line, column, and scatter graphs. These visualizations make it easy to identify differences, track changes over time, and assess compliance with safety standards**.** The graph above shows the RF strength of the NIR emitted by different towers within the boundaries of the city of Barishal. As before, the optimum range of safe exposure to RF strength is below 45 µW/m^2. But to our surprise, all of the towers crossed the safety threshold with Tower 4 and 1 being the highest to cross the safety level as they were found to have 4075.6 µW/m^2 and 2365 µW/m^2 respectively.

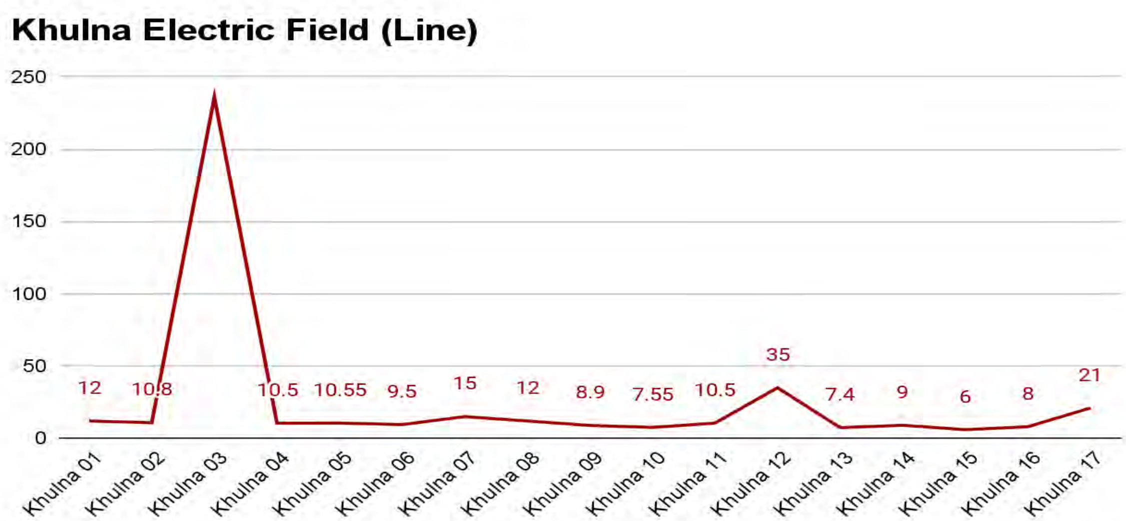


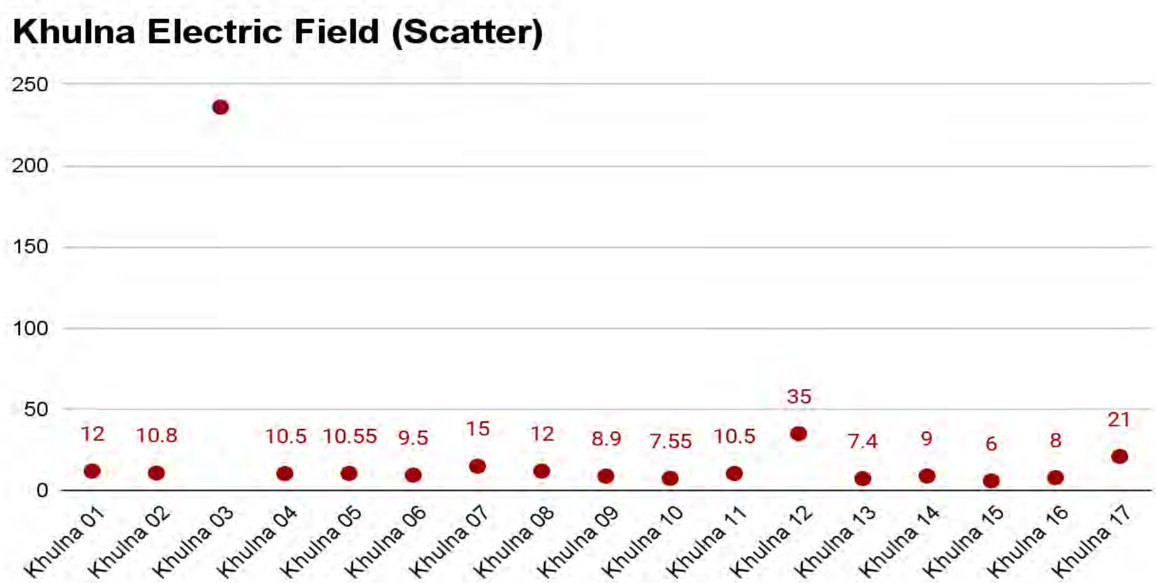


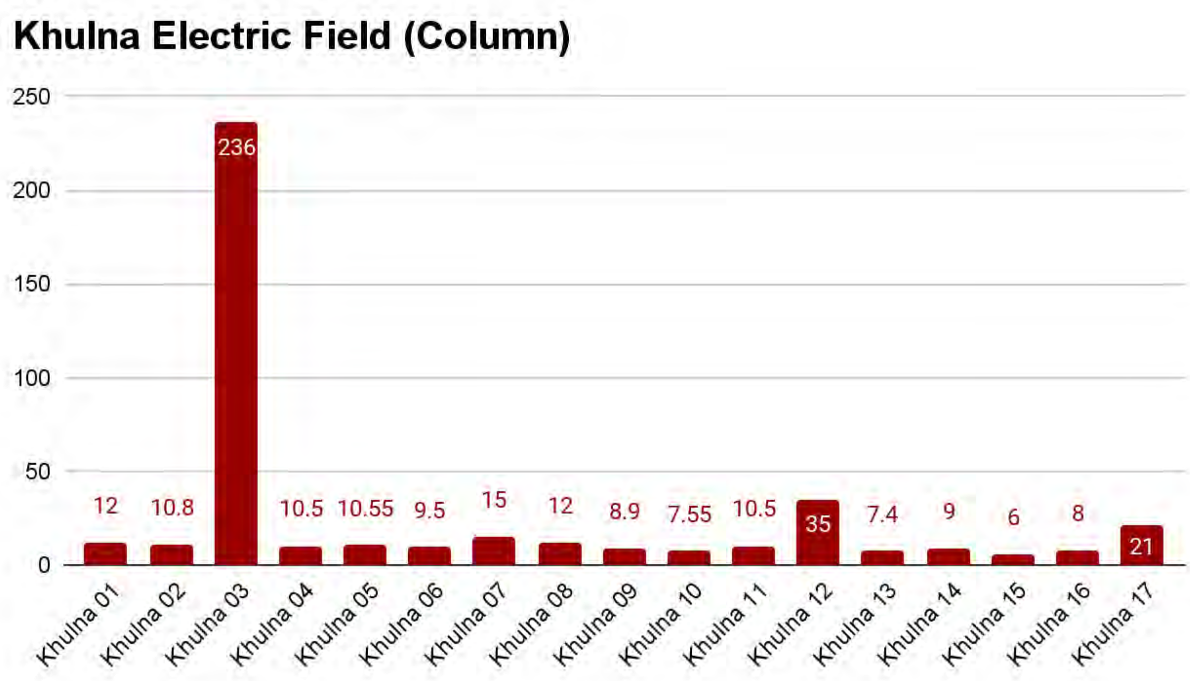


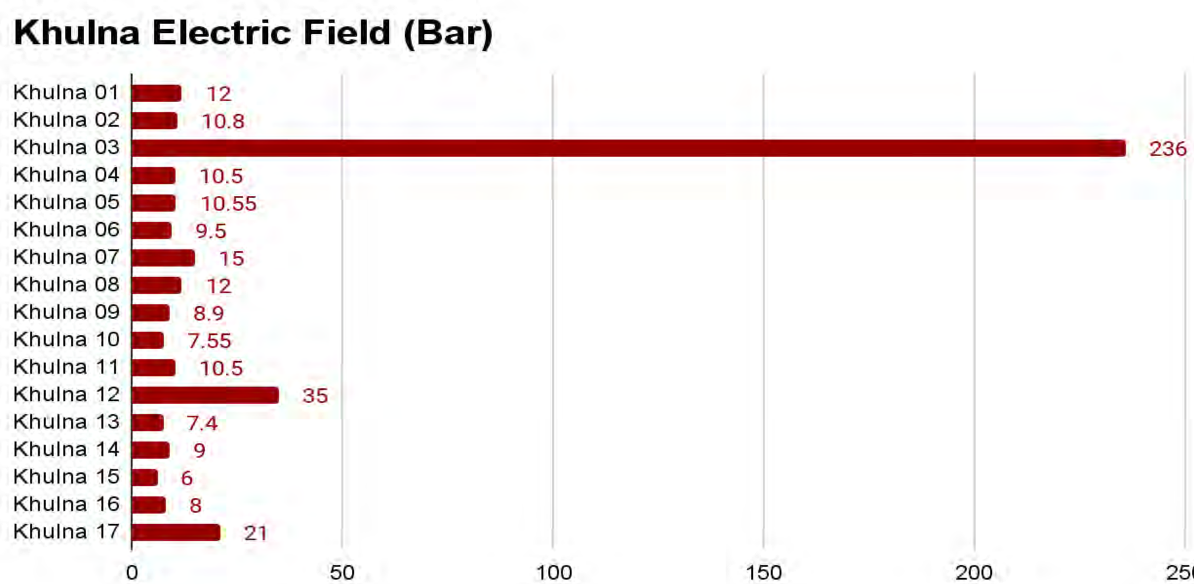


The 4 graphs above display the strength of the varying levels of Magnetic field emitted by the same towers throughout Khulna city. There were 9 cell towers and 8 HVTL towers. The safe level for the Magnetic field for cell towers is approximately 0.1 mG, and for HVTL towers it ranges between 1 milligauss (mG) to 200 milligauss (mG), with strength above this value posing a serious risk to individual health. However, as evident in the graph, all but one of the towers emits radiation that exceeds the safe level, which further jeopardizes the health of the residents of Khulna city. Except for Tower 02 of cell towers, all the towers are emitting Magnetic field of strength that exceeds the standard value of 0.1 mG. For HVTL, all of the 8 towers were found in range.

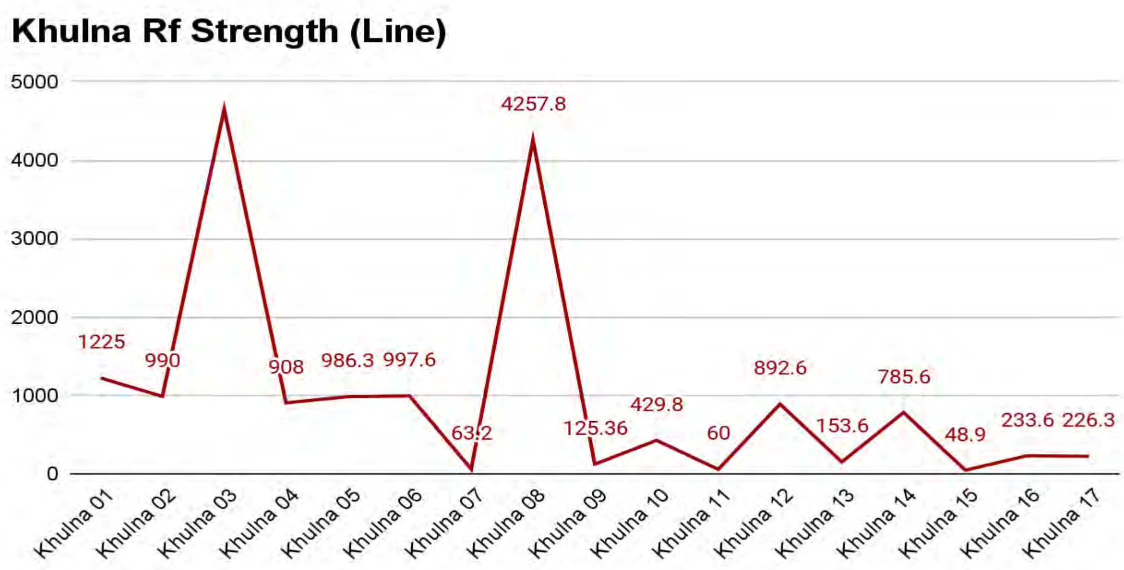


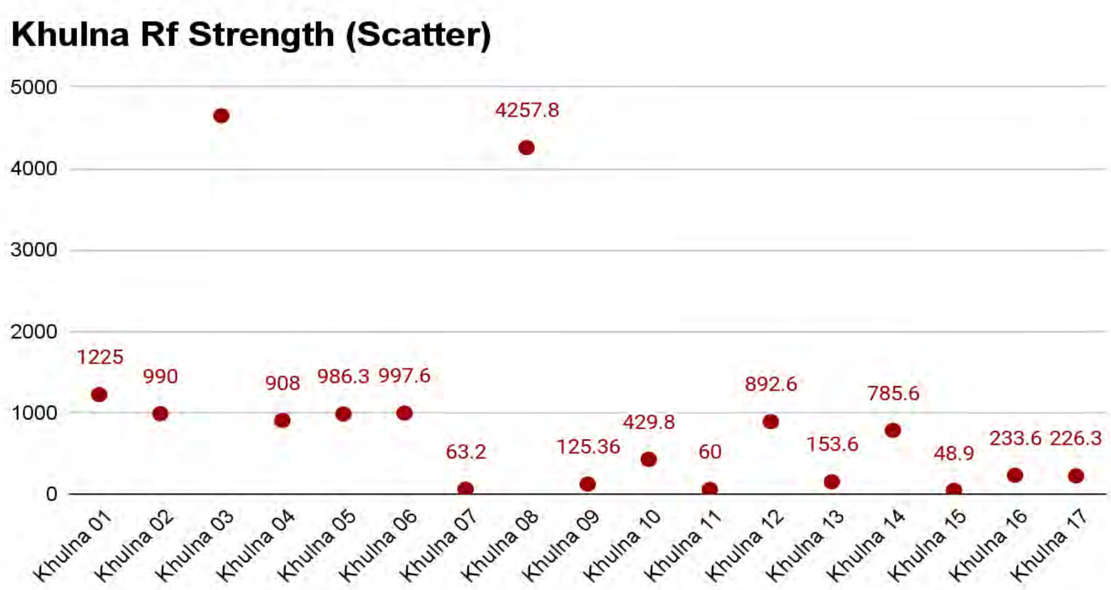


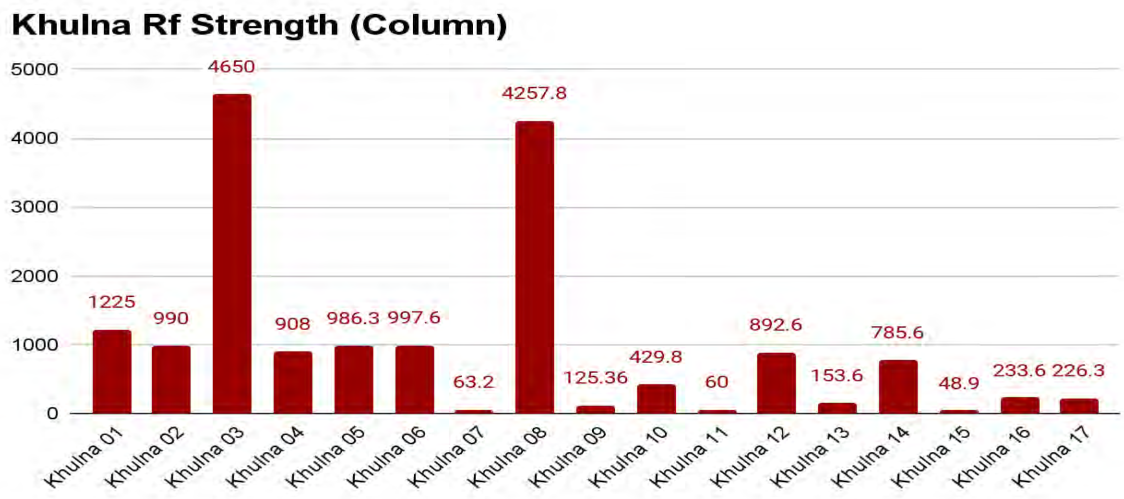


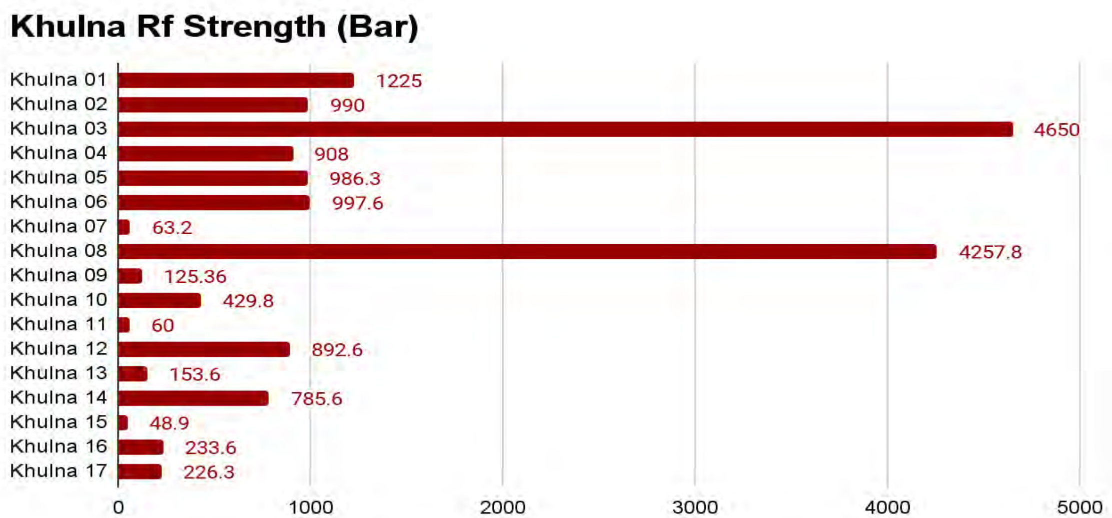


The safe levels for the Electric field emitted by cell towers is between 0.5 V/m and 5 V/m and for High Voltage Transmission Line is 1 kV/m to 10 kV/m. Almost all the cell towers are found to be crossing the threshold level except tower 15 which still crosses the safe level by 1 V/m. As an HVTL Tower, tower 3 emits the highest electric field with around 236 V/m which is way above the safe level. The electric field data from cell towers and HVTL towers in khulna is presented using a combination of bar, line, column, and scatter graphs to facilitate comparison and trend analysis.









The radio frequency (RF) emissions from both cell towers and HVTL towers in khulna were compared and visualized through four different graphs. The optimum range of safe exposure to RF strength is below 45 µW/m^2. However, all of the towers in Khulna city are emitting radiation with RF strength exceeding the safe levels, with Tower 03 and 08 emitting the strongest radiation of them all.

Chapter 09

Discussion

The study of electromagnetic field (EMF) emissions from cell towers and high-voltage transmission lines (HVTL) across various locations provides critical insights into the environmental and health impacts associated with these sources of non-ionizing radiation.

Statistical Correlations and Interrelationships

A fundamental aspect of this study is the correlation analysis between different types of EMF fields. The data indicate a low positive correlation (0.303) between magnetic fields and electric fields. This suggests that while there is a tendency for magnetic fields to increase with rising electric fields, the relationship is relatively weak. This implies that changes in magnetic field levels are not strongly predictive of changes in electric fields. Correlation between Magnetic Field and RF Strength (0.243) , This correlation is negligible correlation. The value is very near to 0. On the other hand, a moderate positive correlation (0.546) between electric fields and RF strength highlights a more substantial interdependence. As electric fields increase, RF emissions also tend to rise, pointing to a more robust relationship between these two types of non-ionizing radiation. This moderate positive correlation between electric fields and RF emissions suggests a notable interaction between these forms of EMF. It implies that areas with higher electric field levels are likely to experience higher RF emissions as well. Such findings are significant because they indicate that increases in one type of EMF field could lead to elevated levels in other fields, potentially resulting in higher cumulative exposure to non-ionizing radiation. This interrelationship underscores the importance of considering multiple types of EMF exposure when evaluating potential health risks.

Graphical Analysis and Regional Variations

The graphical representation of EMF data across various locations offers valuable insights into the compliance with safety standards and variations in emissions. For magnetic field intensities, the analysis reveals that cell towers in Dhaka consistently exceeded the safety threshold of 0.1 milligauss (mG). This finding is concerning, as it suggests that individuals in proximity to these cell towers might be exposed to higher levels of magnetic fields than recommended. In contrast, HVTL towers in Dhaka displayed a broader range of emissions but generally stayed within acceptable limits, indicating better adherence to safety standards for these structures.

Similar patterns are observed in other locations. For example, in Jamalpur and Savar, cell towers frequently surpassed the optimal safety thresholds for magnetic fields, indicating a widespread issue of elevated emissions. The HVTL towers in these areas, however, remained within the prescribed limits, demonstrating a more controlled and safer range of emissions. This contrast between cell towers and HVTL towers highlights the need for targeted regulatory measures to address the specific issues associated with cell tower emissions. The electric field data further illustrate the variability in emissions across different regions. Cell towers in most locations, including Magura and Naogaon, were found to exceed the safety limits of 0.5 V/m to 5 V/m. This trend indicates a persistent issue with elevated electric field emissions from cell towers, raising concerns about the potential health impacts of prolonged exposure. In contrast, HVTL towers generally adhered to the safety ranges for electric fields, reflecting better compliance with established guidelines. RF emissions also present a troubling picture. The data reveal that many cell towers across different cities exceed the safety threshold of 45 $\mu W/m^2$. For instance, in Barishal, all the towers surpassed the recommended safety limits, with some reaching significantly higher levels. Similarly, in Khulna, RF emissions from most towers exceeded the safety range, with Tower 03 and Tower 08 recording the highest emissions. These findings underscore a critical issue with RF exposure from cell towers, which could pose serious health risks if not addressed.

Radiation Awareness Nexus

As evident from the results, most of the recorded cases fall in line with the hypothesis of the research. Most of the towers in the country are emitting radiation of strength that far exceeds the standard values Magnetic Field, Electric field, and Radio Frequency especially evident in the capital city of Dhaka. Most of the towers found in the urban regions of the country are rooftop cell towers, aside from a few open-field high voltage power lines located in the outskirts. The extreme high concentration of NIR on the rooftop, stemming from the densely-packed numerous rooftop towers dotting the city skylines, are especially harmful to flora, often found in the many household gardens. Many stores and habitats have also been developed in close vicinity of the towers, further jeopardizing the health of the citizens. Social awareness regarding this issue is still mostly nonexistent. The administration must take drastic steps to warn the affected people about the forthcoming danger of living in such proximity to the harmful cell towers. Raising social awareness regarding this issue would go a long way in ensuring the health safety of the people in the near future. The study's findings on non-ionizing radiation (NIR) exposure from cellular towers and high-transmission power lines necessitate a multifaceted approach to public health and environmental policy. These findings should inform the necessity for updating and tightening exposure regulations and standards, taking into account the most recent scientific insights into the health impacts of NIR. It's essential to implement preventive actions, such as reconsidering the locations of towers and establishing protective zones to reduce people's exposure. Additionally, there should be improved oversight and enforcement to guarantee that these safety standards are consistently met. Policies should also support ongoing public health surveillance and research into NIR's long-term effects, coupled with public awareness and education initiatives to empower individuals with knowledge about NIR exposure risks. Moreover, international collaboration is vital for harmonizing exposure standards and sharing best practices. Together, these policy directions aim to mitigate NIR exposure risks, safeguarding public health and the environment by fostering a proactive, informed, and coordinated response to the challenges posed by electromagnetic radiation

The findings from this study have important implications for public health and regulatory practices. The frequent exceedance of safety thresholds for magnetic fields, electric fields, and RF emissions from cell towers suggests a potential risk to individuals living near these sources of EMF. Prolonged exposure to elevated levels of non-ionizing radiation could have cumulative effects, potentially leading to health issues such as electromagnetic hypersensitivity or other related conditions. Given the observed patterns, it is essential to implement stricter regulatory measures to ensure that EMF emissions from both cell towers and HVTL towers remain within safe limits. This may involve more rigorous monitoring of emissions, regular inspections, and enforcement of safety standards. Additionally, there may be a need for updated guidelines that reflect the latest research on the health effects of EMF exposure. Public awareness and education also play a crucial role in mitigating potential health risks. Individuals should be informed about the potential sources of EMF and encouraged to take precautions if they live near high-emission areas. This could include measures such as maintaining a safe distance from cell towers and HVTL lines or using shielding technologies where applicable.

Chapter 10
Future Perspectives

As we look to the future, raising awareness about non-ionizing radiation (NIR) and its potential effects on human health becomes increasingly crucial. Non-ionizing radiation, which includes electromagnetic fields (EMFs) from sources such as radio waves, microwaves, and visible light, contrasts with ionizing radiation (like X-rays and gamma rays) in that it does not possess enough energy to ionize atoms or molecules. While it is generally considered less harmful than ionizing radiation, growing concerns about its health effects necessitate a proactive approach to awareness and research.

Future perspectives on raising awareness about NIR must be rooted in comprehensive research. Although non-ionizing radiation has been widely studied, there are still gaps in understanding its long-term effects on human health. Research should focus on epidemiological studies, experimental investigations, and cross-disciplinary collaborations to elucidate potential health impacts, particularly concerning newer technologies like 5G and beyond. To raise awareness effectively, we need to disseminate clear, evidence-based information. Public health campaigns should emphasize the distinction between ionizing and non-ionizing radiation while highlighting ongoing research and emerging findings. This will ensure that the public remains informed about both established knowledge and new developments. Awareness campaigns should be tailored to different audiences, including the general public, policymakers, and healthcare professionals. For the general public, straightforward, accessible information is key. This might include infographics, educational videos, and public service announcements that explain what non-ionizing radiation is, how it differs from ionizing radiation, and what the current scientific consensus is regarding its health effects. For policymakers, targeted briefings and policy papers can provide a nuanced understanding of the implications of NIR. Policymakers need to balance technological advancements with public health considerations, and their decisions will benefit from clear, evidence-based input on the risks associated with NIR. Healthcare professionals also require ongoing education to stay updated on the latest research. Integrating NIR-related content into medical training and continuing education will enable healthcare providers to better inform and advise patients who may have concerns about exposure to EMFs and other forms of non-ionizing radiation.

As technological advancements continue to introduce new sources of non-ionizing radiation, regulatory frameworks must evolve to address potential risks. Future efforts should focus on ensuring that regulations are based on the latest scientific evidence and that they effectively protect public health. This might involve setting stricter exposure limits, mandating transparency in the use of non-ionizing radiation-emitting technologies, and supporting research into safety standards. Public awareness campaigns should advocate for robust regulatory oversight and encourage community involvement in discussions about acceptable exposure levels and safety measures. Engaging the public in regulatory processes can lead to more informed and balanced policies that reflect community concerns and scientific evidence. Promoting Technological Innovations- The future of raising awareness about NIR also involves encouraging the development and adoption of technologies that minimize exposure. Innovations in design and engineering can reduce the amount of non-ionizing radiation emitted by devices, improving safety without compromising functionality. Raising awareness about these innovations and supporting their implementation can be an effective way to mitigate potential risks associated with NIR. Public awareness campaigns can spotlight technological advancements that prioritize health and safety, promoting products and practices that align with the latest research. By fostering a culture of innovation that values safety, we can help drive the development of new technologies that are both effective and environmentally responsible. Addressing Public Concerns and Misconceptions- Finally, it is essential to address public concerns and misconceptions about non-ionizing radiation. Misinformation can lead to unnecessary fear and resistance to beneficial technologies. Future awareness initiatives should include efforts to correct misconceptions, clarify scientific findings, and provide balanced perspectives on the potential risks and benefits of non-ionizing radiation. Engaging with communities, providing clear answers to frequently asked questions, and addressing specific concerns through interactive platforms can help build trust and promote informed decision-making. By fostering open dialogue and transparency, we can bridge the gap between scientific knowledge and public perception, ensuring that people are well-informed and empowered to make decisions about their health.

In conclusion, raising awareness about non-ionizing radiation and its effects on human health requires a multifaceted approach that includes expanding research, educating various audiences, enhancing regulatory frameworks, promoting technological innovations, and addressing public misconceptions. By adopting these strategies, we can ensure that society is well-prepared to navigate the complexities of non-ionizing radiation in a way that prioritizes both technological advancement and public health

Chapter 11
Limitations

This research endeavor set out with the ambitious goal of investigating the overall impacts of non-ionizing radiation (NIR) on public health. However, it is important to acknowledge several limitations and challenges encountered during the study, which affected the depth and quality of the findings. Despite the best efforts to comprehensively understand the effects of NIR, the methodologies employed were primarily effective in elucidating the physical impacts of this form of radiation, leaving a large void in our understanding of its internal biological impacts.

Physical measurements: One of the major limitations of the research was the focus on physical measurements of NIR, which provided valuable but incomplete insights. The investigation methods were adept at quantifying aspects such as radiation strength and exposure levels in various locations. However, these methods fell short of addressing the more nuanced internal biological impacts of NIR exposure. These biological effects include potential cellular or molecular changes, as well as long-term health consequences that are not easily measured through physical instrumentation alone. The absence of comprehensive biological data means that the study could not fully catalog how NIR might affect human health at a cellular or systemic level, a crucial aspect for understanding potential health risks.

Lack of cooperation of subjects: Another significant challenge encountered during the research was related to the cooperation of subjects during fieldwork. Effective data collection often relies on the willingness and engagement of participants to provide accurate and detailed responses to research inquiries. Unfortunately, in this study, some participants were not sufficiently cooperative when answering questions, which compromised the richness and reliability of the data collected. This lack of cooperation introduced variability and potential bias into the dataset, which in turn affected the quality and interpretability of the final results. The researchers had to contend with incomplete or inconsistent information, which posed a challenge for drawing definitive conclusions and making informed recommendations based on the collected data.

Unplanned infrastructure of Dhaka city: Compounding these issues was the lack of strategic planning in the development and placement of NIR towers throughout the country. The research was conducted in Dhaka, a city known for its rapid and often unplanned urban growth. This characteristic of Dhaka led to significant challenges in locating and measuring radiation fields accurately. The disorganized placement of NIR towers meant that some areas were either under-monitored or had overlapping radiation measurements, leading to difficulties in creating a comprehensive map of radiation exposure across different parts of the city. The lack of standardized planning and coordination in the development of these towers further complicated efforts to gather consistent and reliable data.

Time constraints: In addition to these challenges, the research team faced logistical issues related to the unplanned nature of the city's infrastructure. Dhaka's rapid urbanization and informal development patterns made it difficult to establish a coherent framework for measuring radiation exposure. Areas with high-density development and informal settlements posed particular difficulties, as these regions were often characterized by a lack of infrastructure and systematic organization. This made it challenging to position measurement equipment effectively and to ensure that radiation levels were accurately recorded across diverse urban settings.

On top of this, time was a significant factor that limited the overall outcome of this particular pursuit. Generally, a period of at least 4-5 years must be reserved to observe the full morphological cycle of most plants and animals. For instance, a mango tree takes an average of 8-10 years to grow into an adult and bear fruits. It would not be feasible to observe a single mango tree for a full period of 8-10 years. Thus, time constraints also had a noticeable impact on the quality of the final data.

The interplay of these factors highlights the complexity of researching the impacts of NIR in an unplanned urban environment. The physical measurement of radiation, while important, provides only a partial picture of the potential health impacts. Without a thorough understanding of the biological effects and reliable and consistent data collection practices, drawing comprehensive conclusions about the public health implications of NIR remains challenging. Additionally, the unplanned nature of Dhaka's urban development added layers of difficulty to the research process, impacting both data collection and analysis.

Future studies should benefit from addressing these limitations by incorporating methods that can better capture biological effects, improving participant engagement strategies, and developing more structured planning for the placement of measurement infrastructure. By addressing these issues, researchers can enhance the reliability and depth of their findings, ultimately contributing to a more nuanced understanding of how non-ionizing radiation affects public health. Such improvements would be crucial for informing public policy and health recommendations related to NIR exposure and its potential impacts.

Chapter 12

Conclusion

In conclusion, this study demonstrates the critical need to address the growing concerns surrounding non-ionizing radiation (NIR) emissions from cell towers and high-voltage transmission lines (HVTL) in both rural and urban regions of Bangladesh. The research findings clearly show that, while HVTL towers generally comply with international safety standards, emissions from many cell towers frequently overthrow the World Health Organization's (WHO) suggested limit for radio frequency (RF), electric fields, and magnetic fields. This level of exposure presents a tangible risk to the health of not just humans but also animals and plants within the vicinity of these structures. This study's detailed analysis showed that areas with higher levels of non-ionizing radiation (NIR), especially around cell towers, had more reported cases of health problems, both physical and mental. People living near these towers often experience issues like headaches, sleep disturbances, and anxiety. Moreover, significant growth retardation was also seen in plants and crops surrounding the towers. This suggested a potential link between high NIR exposure and negative environment and health outcomes.

Additionally, the research found a moderate positive relationship between electric field strength and radio frequency (RF) emissions. This means that areas with stronger electric fields also tended to have higher levels of RF radiation, which could increase the overall exposure to harmful radiation. This combined effect raises more concerns about the potential health risks in these areas, particularly for people who live or work close to the towers for long periods. The graphical representation of EMF data across various locations offers valuable insights into compliance with safety standards and variations in emissions.

Despite these significant findings, the study encountered several limitations that must be acknowledged. One major limitation was the primary focus on physical measurements of NIR, which provided valuable data on radiation strength and exposure levels but did not capture the more nuanced internal biological impacts of NIR exposure. This gap means that the study could not fully assess how NIR affects human health at a cellular or systemic level, which is crucial for understanding potential long-term health risks.

The implications of these findings are far-reaching, emphasizing the need for immediate action to regulate and monitor NIR emissions more effectively. Public health policies must be updated to reflect the current understanding of NIR's effects, particularly in densely populated areas where prolonged exposure to elevated radiation levels is a concern. Establishing stricter guidelines for tower placement, particularly near residential zones, implementing protective measures, and enforcing compliance with safety standards are crucial steps in reducing exposure risks.

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