THE INVISIBLE THREAT: NIR ON HOME APPLIANCES & YOUR HEALTH

By

Mehedi Hassan Durjoy

20336015

Maliha Sarkar

20236016

Arpa Chowdhury Polin

18236012

A thesis submitted to the Department of Mathematics and Natural Sciences in partial fulfillment of the requirements for the degree of B.Sc. in Biotechnology

Department of Mathematics and Natural Sciences

Brac University

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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.

Students Full Name and Signatures:

Mehedi Hassan Durjoy

20336015

Maliha Sarkar

20236016

Arpa Chowdhury Polin

18236012

Approval

The thesis/project titled "EFFECTS OF NON-IONIZING RADIATION OF CELL TOWER (CT) AND HIGH VOLTAGE TRANSMISSION LINE (HVTL) ON PLANTS, ANIMALS AND HUMANS" submitted by

1. Mehedi Hassan Durjoy (20336015)
2. Maliha Sarkar (20236016)
3. Arpa Chowdhury Polin (18236012)

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Examining Committee:

Supervisor:
(Member)

____

Dr. Munima Haque.
Associate Professor, Biotechnology Program Director,
Department of Mathematics and Natural Science
School of Data and Sciences (SDS), BRAC University.

Program Director:
(Member)

____

Dr. Munima Haque
MS and BS Biotechnology Program Director & Associate Professor, Department of Mathematics and Natural Science
School of Data and Sciences (SDS), BRAC University.

Departmental Head:
(Chair)

____

Dr. Firoze Haque
Associate Professor and Chairperson,
Mathematics and Natural Science,
School of Data and Sciences (SDS), BRAC University

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Abstract

This study investigates the non-ionizing radiation (NIR) emissions from household appliances, focusing on magnetic fields, electric fields, and radio frequency (RF) emissions. By analyzing various appliances such as cell phones, televisions, air conditioners, and laptops, the research assesses the safety of these devices according to established NIR emission standards. Utilizing both statistical and graphical analysis, the study highlights significant variations in emission levels, with some appliances exceeding recommended safety thresholds. The findings suggest that while most household devices operate within safe limits, others, particularly laptops and certain kitchen appliances, exhibit elevated RF and electric field emissions that may pose potential health risks. This research underscores the need for continuous monitoring of NIR emissions, the enforcement of stricter safety regulations, and improved consumer education regarding the potential hazards of prolonged exposure. Furthermore, the study explores the feasibility of applying NIR technology in enhancing appliance performance, promoting safer, more sustainable, and technologically advanced home environments.

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Chapter 01

Introduction

Home appliances, the unsung heroes of our daily lives, play a crucial role in simplifying our tasks, enhancing our comfort, and contributing to a more efficient and enjoyable living experience. These versatile machines, ranging from the ubiquitous refrigerator to the sophisticated dishwasher, have become indispensable companions in modern households.

The evolution of home appliances has been a remarkable journey, reflecting the ingenuity and innovation of human thought. From the early days of hand-powered appliances to the marvels of modern technology, these devices have undergone a transformation that has revolutionized the way we live. The history of home appliances is intertwined with the advancement of technology and the changing needs of society. Early appliances, such as stoves and washing machines, were rudimentary devices that relied on manual labor or simple mechanisms. However, the Industrial Revolution ushered in a wave of innovation, leading to the development of more sophisticated and efficient appliances. The 20th century witnessed an explosion of new home appliances, driven by factors such as urbanization, rising incomes, and the increasing role of women in the workforce. Refrigerators, washing machines, dishwashers, and other appliances became commonplace, freeing up time for families and transforming domestic chores. In recent years, the digital revolution has further revolutionized home appliances, with the advent of smart appliances that connect to the internet and can be controlled remotely. These appliances offer a range of benefits, including enhanced convenience, improved energy efficiency, and personalized user experiences.

In this comprehensive introduction to home appliances, we delve into the fascinating world of these indispensable household companions. We explore their history, explore their diverse range of functionalities, and examine their impact on our lives.

A Glimpse into the History of Home Appliances

The origins of home appliances can be traced back to the earliest civilizations when humans sought ways to ease their daily chores and enhance their living conditions. Simple tools and devices, such as mortars and pestles for grinding grains, were the precursors of modern appliances.

The Industrial Revolution marked a turning point in the evolution of home appliances. With the advent of mechanization and mass production, appliances became more sophisticated and accessible to a wider range of households. Electricity further propelled the development of home appliances, paving the way for a new era of convenience and automation.

A Diverse Range of Functionalities

Home appliances encompass a vast spectrum of functionalities, catering to every aspect of household management and personal well-being. They can be broadly categorized into three main groups:

1. Kitchen Appliances: These appliances are the backbone of any kitchen, facilitating food preparation, cooking, and storage. They include refrigerators, ovens, dishwashers, blenders, and a wide array of other specialized devices.
2. Cleaning Appliances: These appliances maintain a clean and hygienic environment, taking care of tasks such as vacuuming, washing laundry, and deodorizing. They have transformed the way we maintain our homes, saving time and effort.
3. Personal Care Appliances: These appliances enhance our personal well-being and appearance. They include hairdryers, shavers, and various grooming devices.

Impact on Our Lives

Home appliances have profoundly impacted our lives, transforming the way we manage our homes, prepare our meals, and care for ourselves. They have contributed to a more efficient, comfortable, and enjoyable living experience.

1. Increased Productivity: Home appliances have freed up our time and energy, allowing us to focus on other aspects of our lives. They have reduced the time spent on mundane tasks, enabling us to be more productive in other areas.
2. Enhanced Comfort: Home appliances have made our homes more comfortable and convenient. They provide us with clean environments, hot meals, and the means to maintain our appearance.
3. Improved Health and Well-being: Home appliances have contributed to improved health and well-being by promoting hygiene, facilitating healthy cooking habits, and reducing physical strain.

Kitchen Appliances:

The kitchen is the heart of many homes, and it is here that home appliances play a pivotal role. Kitchen appliances include:

1. Refrigerators and freezers: These essential appliances keep our food fresh and safe for consumption.
2. Stoves and ovens: These appliances provide the power to cook a variety of dishes, from simple snacks to elaborate meals.
3. Dishwashers: These labor-saving appliances eliminate the chore of washing dishes by hand.
4. Microwaves: These versatile appliances offer quick and convenient heating and cooking options.
5. Coffee makers: These appliances provide the perfect way to start the day with a fresh cup of coffee.

Laundry Appliances:

Laundry is an essential chore, and laundry appliances make the process more efficient and less time-consuming. Common laundry appliances include:

1. Washing machines: These appliances clean clothes using a combination of water, detergent, and agitation.
2. Dryers: These appliances remove moisture from clothes, leaving them ready to wear or store.
3. Ironing boards and irons: These appliances remove wrinkles and creases from clothes, giving them a polished appearance.

Cleaning Appliances:

Cleaning is an essential part of maintaining a clean and healthy home. Cleaning appliances make the process easier and more effective. Common cleaning appliances include:

1. Vacuums: These appliances remove dust, dirt, and debris from floors and carpets.
2. Mops and brooms: These traditional cleaning tools are still widely used to clean floors.
3. Cleaning robots: These innovative appliances automate the cleaning process, freeing up time for other tasks.

Entertainment Appliances:

Entertainment appliances provide a source of leisure and relaxation in the home. Common entertainment appliances include:

1. Televisions: These devices provide access to a vast array of entertainment content, including movies, TV shows, and streaming services.
2. Stereo systems: These appliances deliver high-quality audio for music and other forms of audio entertainment.

3. Gaming consoles: These devices provide a platform for video games, offering immersive and interactive entertainment experiences.

The Impact of Home Appliances on Modern Living

Home appliances have had a profound impact on modern living, transforming our homes into more efficient, comfortable, and enjoyable spaces. They have:

1. Increased Productivity: Home appliances have freed up time for individuals and families, allowing them to focus on work, education, and leisure activities.
2. Enhanced Comfort and Convenience: Home appliances have made everyday tasks less demanding, providing a higher level of comfort and convenience in our homes.
3. Improved Health and Safety: Home appliances have contributed to healthier and safer homes by facilitating food preservation, sanitation, and personal hygiene.
4. Promoted Culinary Creativity: Home appliances have opened up new culinary possibilities, enabling individuals to explore diverse cuisines and experiment with new recipes.

Home appliances, once considered mere tools, have evolved into essential components of modern households. They have revolutionized our daily lives, transforming the way we manage our homes, prepare our meals, and care for ourselves. As technology continues to advance, we can expect even more innovative and sophisticated home appliances to emerge, further enhancing our living experience.

In the modern home, we rely on a myriad of appliances to perform essential tasks, from preparing meals to maintaining a comfortable environment. These appliances, while enhancing our daily lives, also emit radiation, which can be broadly categorized into two types: ionizing and non-ionizing. Understanding the distinction between these two forms of radiation is crucial for making informed decisions about appliance usage and potential health implications.

Ionizing Radiation: A Force for Good, but with Caution

Ionizing radiation, as the name suggests, possesses enough energy to remove electrons from atoms, creating charged ions. This process can disrupt cellular structures and potentially lead to DNA damage, increasing the risk of cancer. Sources of ionizing radiation include medical X-rays, radioactive materials, and high-energy particles from the sun. While ionizing radiation plays a vital role in diagnostic procedures and cancer treatment, exposure to excessive amounts can have detrimental health consequences.

Non-Ionizing Radiation: A More Benign Form

In contrast to ionizing radiation, non-ionizing radiation lacks the energy to ionize atoms. Instead, it primarily interacts with matter by causing vibrational motion, which translates into heat. Common sources of non-ionizing radiation in the home include radio waves, microwaves, and infrared radiation. These forms of radiation are generally considered safe at low levels, but prolonged or high-intensity exposure can lead to adverse effects, such as skin burns or eye damage.

As we increasingly rely on technology in our homes, it becomes increasingly important to understand the potential health implications of the electromagnetic radiation emitted by our appliances. While ionizing radiation poses a more significant health risk, non-ionizing radiation should not be disregarded entirely. By adopting responsible usage practices and following safety guidelines, we can continue to enjoy the benefits of modern appliances without compromising our well-being.

Chapter 02

Background/ Overview

Home appliances, often regarded as the unsung heroes of daily life, play a pivotal role in simplifying household tasks, enhancing comfort, and contributing to an efficient and enjoyable living experience. These versatile devices, ranging from basic refrigerators to advanced dishwashers, have become indispensable in modern households. The journey of home appliances reflects remarkable human ingenuity and innovation, evolving from hand-powered tools to sophisticated machines that integrate seamlessly into daily routines.

The history of home appliances is closely linked with technological advancements and societal changes. Initially, appliances like stoves and washing machines were basic and relied heavily on manual labor. However, the Industrial Revolution sparked a wave of innovation, leading to the creation of more efficient and accessible appliances. The 20th century saw an explosion of new appliances due to factors like urbanization, rising incomes, and the increasing participation of women in the workforce. Modern times have ushered in the digital revolution, introducing smart appliances that offer enhanced convenience, energy efficiency, and personalized experiences.

In this comprehensive introduction, we explore the fascinating history, diverse functionalities, and significant impact of home appliances on our daily lives. These devices have revolutionized home management, personal care, and overall living standards, highlighting their essential role in contemporary life.

Exposure to electromagnetic fields (EMF) varies significantly across industries, professions, and individuals. EMFs, including 50-Hertz magnetic fields (MF) and radiofrequency (RF) fields, are prevalent in factories and large commercial buildings housing office equipment such as computers and photocopiers. A study aimed to determine the occupational MF personal exposure of operators using industrial workstations and office equipment for at least eight hours a day. Measurements were conducted at two national banks, a global satellite and cable operator, and a fuel injection factory using an isotropic probe and a Narda EFA-300 meter to calculate the mean and maximum MF magnitudes at extremely low frequency (ELF). The study highlights the importance of regular EMF exposure measurements to better understand occupational exposures and their sources, and to reduce the risk of harm from non-ionizing electromagnetic fields at work. It also emphasizes the need for swift implementation of occupational exposure guidelines globally, considering the precautionary principle.

The study found that in four companies with 5,632 workers/operators, 697 points were measured, indicating that approximately 72% of the staff is at risk according to IARC and WHO 2001 classifications. The gasoline injection factory had the highest mean and maximum MF values. Issues often arise from offices being near high-power electrical appliances or electric enclosures. The study also discusses electrohypersensitivity (EHS), recognizing it as a distinct neurologic pathological illness linked to various chemical sensitivities. It discredits the nocebo effect theory and emphasizes that EMF exposure can cause objective pathophysiological changes and adverse health effects.

A systematic review protocol aims to evaluate the impact of RF-EMF on human symptoms, including perception accuracy of exposure among those with and without idiopathic environmental intolerance to electromagnetic fields (IEI-EMF). Another study estimates the number of childhood leukemia cases in the EU linked to ELF MF exposure, suggesting a need for better residential exposure tracking and more research.

Longitudinal studies on RF exposure at the population scale reveal increased exposure primarily from Wi-Fi, while regulatory limits for cellular exposure are generally met. Studies on IEI-EMF using ecological momentary assessment methods indicate no single etiology for IEI-EMF, suggesting biophysical backgrounds in some cases but not others.

Research on non-ionizing radiation (NIR) emphasizes the need for improved protective measures and highlights the lack of long-term consequences compared to other physical agents. Public awareness efforts are crucial to understanding EMF exposure and its safety, with studies suggesting current exposure levels are generally safe. The biological impacts of NIEMFs, including chromosomal abnormalities and infertility, require more extensive research to establish comprehensive guidelines for exposure limits. Studies on the effects of low-frequency EMF on oxidative stress in rat brains found no significant differences in stress levels between exposed and control groups.

Overall, the varied findings underscore the complex relationship between EMF exposure and health effects, necessitating ongoing research, better tracking, and improved public awareness and protective measures.

In the 21st century, our homes have become sanctuaries for a multitude of modern gadgets seamlessly integrated into our daily lives. From the gentle hum of the microwave in the morning to the glow of our smartphones at night, these electronics have become essential to our routines. However, accompanying this convenience is non-ionizing radiation, an invisible force emitted by these devices that warrants careful consideration regarding its impact on our health and well-being.

Non-ionizing radiation encompasses a range of electromagnetic waves emitted by common household items. Unlike ionizing radiation, which has enough energy to ionize atoms and molecules, non-ionizing radiation lacks this power, presenting a lower immediate risk. Nonetheless, the pervasive presence of non-ionizing radiation due to the ubiquity of technology in modern homes raises questions about the potential long-term effects of continuous exposure.

As our homes have evolved into high-tech environments filled with devices designed to enhance our comfort and efficiency, we are constantly surrounded by sources of non-ionizing radiation, such as microwave ovens, Wi-Fi routers, cell phones, and household electrical wiring. This omnipresence necessitates a deeper understanding and awareness of the electromagnetic fields generated by these devices.

This research aims to shed light on the nature of non-ionizing radiation, its sources, and its potential health implications. By increasing awareness and understanding of the electric fields around us, individuals can make informed decisions about their use of these devices. This overview delves into the types and frequencies of electromagnetic fields emitted by household appliances, examining their impact on our daily lives and overall well-being.

Near-infrared (NIR) radiation is a type of non-ionizing electromagnetic radiation that lies between visible light and infrared radiation on the electromagnetic spectrum. Though invisible to the human eye, NIR radiation can be detected by electronic devices and is widely utilized in various fields, including medical imaging, telecommunications, and food processing. Recently, there has been growing interest in the application of NIR radiation in home appliances, marketed for their potential health benefits.

A comprehensive literature search of studies published in the last decade identified 54 relevant studies, revealing mixed results on the health effects of NIR radiation. Some research indicates beneficial effects, such as improved circulation, reduced pain and inflammation, enhanced wound healing, better skin health, reduced stress, and improved sleep. However, other studies highlight potential risks, including eye damage, increased cancer risk, and premature skin aging, particularly with prolonged exposure to high-intensity NIR radiation.

NIR home appliances, such as saunas, blankets, lamps, and mats, are designed to harness NIR radiation for various health benefits. While some studies support these claims, the scientific evidence remains inconclusive, and more research is needed to confirm the therapeutic effects of NIR radiation.

The health impact of NIR radiation depends on factors such as wavelength, intensity, and exposure duration. Generally, NIR radiation with wavelengths of 650-850 nm is considered safe, but higher wavelengths can pose risks, particularly to the eyes. To mitigate potential risks, it is essential to use NIR home appliances safely and adhere to guidelines such as limiting exposure time and consulting healthcare providers, especially for individuals with certain health conditions.

Overall, awareness and understanding of the effects of NIR radiation are crucial for making informed decisions about using NIR-emitting devices. By balancing the benefits of technology with cautious use, we can safely integrate these innovations into our daily lives.

The electromagnetic spectrum encompasses the entire range of electromagnetic radiation frequencies, from the lowest to the highest, along with their respective wavelengths and photon energies. This spectrum includes wavelengths ranging from thousands of kilometers to fractions of the size of an atomic nucleus, and frequencies from a few hertz (Hz) to over 10^25 Hz. The human eye can only perceive a small part of this spectrum, known as visible light.

Electromagnetic fields, a form of non-ionizing radiation (NIR), do not produce charged ions when passing through matter but can cause biological effects due to sufficient energy for excitation. Every type of electromagnetic radiation has a unique frequency and wavelength. NIR, which covers a broad range from 1 Hz to 3.10^15 Hz, includes long wavelengths (> 100 nm) with low photon energy (<12.4 eV).

The electromagnetic spectrum is divided into several types of radiation, including radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays. Non-ionizing radiation, which includes radio waves, microwaves, infrared, visible light, and most ultraviolet radiation, is generally considered less harmful compared to ionizing radiation (X-rays and gamma rays), which can remove electrons from atoms or molecules and cause significant biological damage.

The speed of electromagnetic radiation is constant at approximately 299,792,458 meters per second, whether in a vacuum or a medium. This radiation can be transmitted, reflected, or absorbed by materials, and the energy from it is transferred to the medium upon absorption.

Thermal effects of long-term exposure to electromagnetic spectrum radiation, particularly from home appliances, can vary based on radiation type, intensity, and exposure duration. While low-intensity exposure to radio waves, microwaves, and infrared radiation is generally safe, high-intensity exposure can cause heating of body tissues or eye damage. Visible light exposure can lead to eye conditions such as cataracts, and ultraviolet radiation can cause skin damage and increase the risk of skin cancer. Ionizing radiation like X-rays and gamma rays is highly dangerous and can lead to serious health issues, including cancer.

The relationship between wavelength, frequency, and the speed of light in the electromagnetic spectrum is given by the equation

$$c = \lambda f$$

$c = \lambda f$, where

c is the speed of light,

λ is the wavelength, and

f is the frequency. This fundamental relationship demonstrates that wavelength and frequency are inversely proportional.

Long-term exposure to electromagnetic radiation from home appliances can lead to thermal effects, such as reduced efficiency, component failure, and shortened lifespan of appliances. For users, potential risks include skin burns, eye damage, and other health concerns. To minimize these risks, it is important to follow usage instructions, ensure proper ventilation, perform regular maintenance, and maintain a safe distance from appliances.

In the contemporary era, technology is integral to daily life, with home appliances playing a crucial role in enhancing convenience and efficiency. These devices, ranging from refrigerators to washing machines, streamline household tasks and significantly improve the quality of life. However, rapid technological advancement brings challenges related to the performance, safety, and sustainability of these appliances. As consumer demands for efficiency, reliability, and eco-friendliness grow, manufacturers and researchers are exploring innovative solutions to meet these needs.

One promising approach is the application of Non-Ionic Radiation (NIR) technology to home appliances. NIR, which lies between visible light and microwaves on the electromagnetic spectrum, offers the potential for analyzing, monitoring, and optimizing appliance performance. This research aims to explore the feasibility, efficacy, and implications of using NIR technology in home appliances. Key questions include identifying which appliances benefit most from NIR analysis, understanding the impact of electric or magnetic fields on appliance functionality and safety, and examining consumer perceptions and acceptance of NIR-enhanced appliances.

The significance of this research lies in its potential to transform how we interact with and understand home appliances. NIR technology can provide new insights into appliance functionality, durability, and user experience. Additionally, as concerns about energy consumption, environmental impact, and consumer safety rise, NIR technology offers a non-invasive and versatile tool for addressing these challenges. Despite its promise, the application of NIR technology to home appliances is still an emerging field, presenting numerous opportunities for further investigation and development. This research endeavors to advance our understanding of NIR technology and its applications, contributing to improvements in appliance design, manufacturing, and consumer education.

The study employs a mixed-methods research design, combining qualitative and quantitative approaches to comprehensively investigate NIR technology's application to home appliances. Data collection includes questionnaires, interviews, surveys, and NIR spectroscopic measurements. The analysis uses thematic and content analysis for qualitative data and descriptive and multivariate statistical methods for quantitative data. Ensuring the validity and reliability of the findings involves triangulation, member checking, inter-coder reliability, and calibrated NIR measurements.

A diverse range of home appliances, such as phones, air conditioners, laptops, fans, lights, sockets, routers, clocks, and sandwich makers, are selected for NIR analysis. The research also details the specifications and calibration procedures of the Multifield Electromagnetic Field (EMF) Meter used for NIR measurements. This study aims to provide a deeper understanding of NIR technology's potential applications and implications, paving the way for more efficient, sustainable, and technologically advanced home environments.

This research explores the impact of electric and magnetic fields in the context of Near-Infrared (NIR) technology applied to home appliances. Both fields play significant roles in NIR analysis, and their presence can profoundly affect the operation, performance, and safety of household devices. Magnetic fields, generated by motors, transformers, or electronic circuits, can induce currents in conductive materials within appliances, leading to potential issues like unwanted heating, electromagnetic interference (EMI), or component failure. Electric fields, emanating from electrical circuits, capacitive touch interfaces, or high-voltage components, can alter the behavior of charged particles and dielectric materials, causing dielectric breakdown, insulation failure, or undesirable electrostatic effects.

Understanding and mitigating the effects of these fields is crucial for ensuring the safe and efficient operation of home appliances. Proper design optimizations, such as shielding sensitive components and selecting appropriate materials, can enhance appliance reliability and compliance with regulatory standards.

The study involves a comprehensive investigation of these effects by targeting a diverse population, including consumers, industry experts, and researchers. The sample size and selection criteria are carefully determined to ensure statistical validity and representativeness. Data is collected from various locations, including residential areas, electronics stores, and online platforms, ensuring a broad and inclusive sample.

Data analysis encompasses both qualitative and quantitative methods. Thematic and content analyses are used for qualitative data, while descriptive and inferential statistics are applied to quantitative data. The integration of these approaches through mixed-methods analysis provides a holistic understanding of the research topic. Dedicated software tools like NVivo for qualitative analysis and SPSS for quantitative analysis facilitate rigorous data examination. The results are interpreted in the context of the research objectives and theoretical framework, providing valuable insights into the implications of electric and magnetic fields in home appliances. This research aims to inform future developments in appliance design, manufacturing, and consumer safety, ultimately contributing to a more efficient and technologically advanced domestic environment.

The study presented focuses on the non-ionizing radiation (NIR) emissions from various household appliances, providing a thorough analysis of magnetic fields (mG), electric fields (V/m), and radio frequency (RF) emissions ($\mu W/m^2$). The results are compared against established safety standards for each category, and the findings are evaluated using statistical methods, such as one-sample t-tests. Various appliances, including cell phones, televisions, and washing machines, were analyzed to assess compliance with safety limits.

The findings show variability in emissions, with some appliances, like televisions and refrigerators, consistently staying within safety limits, while others, such as laptops and washing machines, exceeded recommended thresholds for RF and electric fields. The study highlights specific appliances that warrant further attention due to their higher emission levels.

In addition to statistical analysis, graphical representations, such as bar and column charts, help visualize the emission levels across appliances. These graphical tools enhance understanding by clearly showing the fluctuations and patterns in the data.

This study underscores the importance of ongoing monitoring and regulation of NIR emissions, particularly as household reliance on technology grows. It calls for continued efforts to raise consumer awareness and encourage safe appliance usage, as well as for manufacturers to implement designs that mitigate radiation exposure risks.

Chapter 03

Literature Review

Exposure to electromagnetic fields differs significantly throughout industries, professions, and individuals. 50-Hertz magnetic fields (MF) as well as radiofrequency (RF) fields are present in factories and big commercial buildings that house a large number of office equipment, such as computers, photocopiers, fax devices, and video display units. Determining the occupational MF personal exposure of operators utilizing industrial workstations and/or office equipment for a minimum of eight hours a day was the aim of this **(Occupational EMF exposure measurements in different work environments)** study on EMF occupational exposure measurement. At two national banks, one global satellite and cable operator, and one fuel injection factory, measurements were carried out. Using an isotropic probe and a Narda EFA-300 meter, the purpose of this study was to calculate the mean as well as maximum MF magnitudes at extremely low frequency (ELF). It is highly advised, in light of the findings in this research paper, to conduct frequent EMF exposure measurements in order to have a greater awareness of occupational exposures, including their sources. Additionally, the outcomes must be taken into account when assessing the risk in order to reduce the likelihood that employees would suffer harm from being exposed to nonionizing electromagnetic fields at work. It is imperative that occupational exposure guidelines be swiftly enacted in Turkey and around the world, taking into account the precautionary principle method for dealing with adverse health impacts.

The result and conclusion of this paper *(Seyhan, 2017)* show that, in a total of four distinct companies with 5,632 workers/operators, 697 points were measured. These findings indicate that, based on IARC and WHO 2001 classifications, approximately 72% of the staff is at risk. The gasoline injection factory, which uses melting and hardening furnaces, has the highest mean as well as maximum MF values, as shown in Tables 1-4. These businesses frequently experience issues with their offices being adjacent to high-power electrical appliances or electric enclosures.

A significant portion of the debate around the etiology of electrohypersensitivity (EHS) stems from the lack of established clinical and biological standards for a generally acknowledged diagnosis **(Why electrohypersensitivity and related symptoms are caused by non-ionizing man-made electromagnetic fields: An overview and medical assessment)** (Mattsson et al., 2022). But currently, there is enough information available to recognize EHS as a separate, well-defined, and objectively diagnosed neurologic pathological illness. It seems that EHS as well as MCS can be identified as distinct neurologic syndromes, regardless of their causal origin, because we have demonstrated that 1) EHS is frequently linked with various chemical sensitivities (MCS) in EHS patients, and 2) both individualized disorders possess an identifiable pathophysiological process that causes symptom occurrence. In this study *(Dominique Belpomme, 2022)*, the authors separate the environmental factors that produce pathophysiological alterations and clinical symptoms subsequent to the onset of EHS from the etiology of the illness itself. Then they unequivocally disprove the theory that a nocebo effect caused the emergence of EHS and its manifestation, notwithstanding the now-present scientifically baseless charges. Additionally, they disprove the false notion that EHS may be boiled down to a nonspecific, unsubstantiated "functional impairment.". However, as they demonstrate here, exposure to electromagnetic fields (EMFs) can cause objective pathophysiological alterations and adverse health effects in both EHS patients and healthy participants. In other words, exposure to excessive non-thermal anthropogenic EMFs is significantly harmful to one's health. The consequences of exceptionally low frequencies, radiofrequency emissions from wireless communications, and electromagnetic fields from microwaves are the main topics of this overview with medical evaluation. In this paper *(Dominique Belpomme, 2022)*, the authors talk about how to define and describe EHS more precisely. Taking into account the proposed causation criteria by the WHO, they demonstrate that there is a causative relationship between increasing exposure to man-made electromagnetic fields (EMF) and, in certain cases, marketed environmental chemicals, and EHS. They thus encourage all governments and global health organizations, notably the WHO, to take immediate action in addressing the escalating epidemic connected with EHS and to recognize EHS as a mostly novel, actual EMF-caused disorder. Since the 1950s, there has been a steady increase in the scientific use of radiofrequency electromagnetic fields (RF-EMF) across several sectors, exposing significant segments of the population. Concerns over the possible effects on people's health have been raised by this fact. As part of its evaluation of the possible health effects of exposure to radiofrequency electromagnetic fields (RF-EMF), the World Health Organization (WHO) conducted an international poll among experts. These experts nominated six priority issues, including the effects on symptoms, that should be further explored through systematic reviews. Here, we describe the technique for a comprehensive assessment of human experimental investigations that evaluated the impact of RF-EMF on symptoms. The purpose of this research **(The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A protocol for a systematic review of human experimental studies)** is to evaluate how electromagnetic field exposure affects human participants' symptoms in comparison to no exposure or exposure at lower levels. Additionally, we'll evaluate how accurately volunteers, both with and without idiopathic environmental intolerance to electromagnetic fields (IEI-EMF) perceive the presence of exposure.

This study *(Capblanch, n.d.)* searches relevant literature sources (such as the Web of Science, Medline, Embase, and Epistemonikos) for randomized crossover trials and randomized trials comparing at least two arms of RF-EMF exposure that evaluate the impact on symptoms. The studies that have assessed how accurately people perceive exposure to be present or absent are also included by the authors of this study. Studies in any language will be included. Two impartial reviewers will evaluate the studies in relation to the inclusion criteria. Using a particular template, two impartial reviewers will collect data on research characteristics, participants, exposure, comparators, and effects. Disputes will be resolved through consensus. The GRADE technique will be used to determine the degree of confidence in the scientific proof of the exposure-outcome linkages, while the ROB Rating Tool for Human as well as Animal Studies will be used to assess the risk of bias (ROB). The authors will employ modified versions of the GRADE evaluation and ROB tools for the perception studies. Meta-analytical approaches will be employed to merge data when suitable.

Though causation is still being studied, pediatric leukemia has been comparatively frequently linked in epidemiological research over the past 20 years to home exposure to exceptionally low-frequency magnetic fields (ELF MF). Using the results of epidemiological research as a guide, this study **(Potential health impacts of residential exposures to extremely low frequency magnetic fields in Europe)** attempted to calculate the number of children with leukemia in the European Union (EU27) that could be linked to exposure to ELF MF. We used research found in the body of literature to determine ELF MF exposure distributions. By utilizing a probabilistic mixture distribution technique, individual exposure distributions were combined. From the most current published pooled study of epidemiological data, exposure-response functions were estimated. In the EU27, population attributable fractions (AFP) and attributable cases of childhood leukemia were estimated by probabilistic simulation. We estimated the total annual number of cases of leukemia attributable to ELF MF at between ~50 (95% CIs: -14, 132) and ~60 (95% CIs: -9, 610), according to whether exposure-response was modeled categorically or continuously, respectively, for non-threshold effect. This was achieved by assigning the literature review-based exposure distribution to all EU27 countries. This translates to around 1.5% to 2.0% of all incidence cases of juvenile leukemia that happen in the EU27 each year *(James Grellier, n.d.)*. Significant uncertainties arise from the lack of exposure data and the selection of the exposure-response model. This highlights *(James Grellier, n.d.)* the need for enhanced tracking of residential exposures to ELF MF in Europe as well as the significance of additional research to better understand the mechanisms of any potential connection between ELF MF exposure and childhood leukemia.

In the final analysis of this study *(James Grellier, n.d.)*, the information available at this time suggests that residential contact with ELF MF may be somewhat responsible for childhood leukemia cases, albeit this relationship is highly ambiguous.

For reliable epidemiological research about the potential health effects of radiofrequency radiation, population-scale exposition to radio frequencies (RF) must be evaluated. Many studies, however, which relied on relatively small population samples, documented community exposure to radiofrequency radiations utilized in wireless telecommunication technology. Under these circumstances, little is known about the population's true exposure. According to known sources, this research **(Longitudinal study of exposure to radio frequencies at population scale)** represents the broadest crowd-based assessment of the amount of radiation that 254,410 unique users in 13 countries were exposed to between January 2017 and December 2020 from cellular antennas, Wi-Fi access points, and Bluetooth devices. Using smartphone readings from the ElectroSmart Android app, this research *(Yanis Boussad, 2024)* first presents techniques to evaluate population exposure to radiofrequency radiation. Next, these techniques are applied in this study *(Yanis Boussad, 2024)* to assess and describe the development of radiofrequency exposure. The authors of this paper demonstrate that, throughout the four years under consideration, overall exposure increased by 2.3, with Wi-Fi accounting for the majority of this increase. The levels of cellular exposure are well below regulatory limits and do not exhibit any correlation with national regulation strategies. The public is generally more exposed at home, as personal Wi-Fi routers as well as Bluetooth devices accounted for more than 50% of the overall exposure for half of the study participants. They demonstrate in this work how crowdsource-based data enable long-term, large-scale assessments of population exposure to radiofrequency radiation.

Examining how population exposure is affected by 5G implementation would be an intriguing next step. In fact, this study *(Yanis Boussad, 2024)* did not include 5G in this analysis because it was not widely deployed in the nations we looked at, and very few smartphones had 5G compatibility prior to 2021. The evaluation of exposure is made more difficult by 5G's usage of millimeter waves, tiny cells, and beam shaping, which modifies exposure during transmission. It will surely be difficult to accurately characterize 5G exposure.

The term "IEI-EMF" describes a self-reported sensitivity that is defined by the attribution of non-specific physical symptoms to exposure to low levels of electromagnetic fields. The majority of empirical findings refute the notion that IEI-EMF and EMF are causally related. This result, nonetheless, was reached based on experimental and environmental research that had certain methodological flaws. This study **(An idiographic approach to Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF) Part II.** (Younes, 2022)**.**

Ecological momentary assessment of three individuals with severe IEI-EMF) (Younes, 2022) examined the temporal relationship between actual radio frequency (RF) EMF exposure as well as IEI-EMF at the person level using an ecological momentary assessment (EMA) technique as part of a sophisticated biopsychosocial approach. A 21-day study involving three individuals with severe IEI-EMF involved continuous monitoring of autonomic variables using holter electrocardiogram (ECG) monitors and personal dosimeters to measure ambient radiofrequency electromagnetic field (RF EMF). Additionally, daily paper-and-pencil assessments of mood, symptoms, and perceived EMF intensity were conducted, as well as situational factors. This study *(Dömötör, 2022)* used time series analytics to look at temporal linkages. The findings for two individuals refuted the hypothesis that reports of symptoms were correlated with the suspected

EMF frequency range or ranges. The IEI-EMF condition is contradicted by the data, which showed an opposite connection with respect to another frequency band (GSM900 down-link).

The results pertaining to autonomic activation were contradictory. The third participant's autonomic reactions (UMTS downlink, total RF, and RMS values) and symptom reports somewhat corroborated the purported connection. The results of this study *(Dömötör, 2022)* point to the lack of a single etiology for IEI-EMF. In some people, it is impossible to rule out a biophysical background, whereas in others, there doesn't seem to be any such underlying cause. The etiology of IEI-EMF can be effectively investigated with the use of EMA. The results of this study *(Dömötör, 2022)* also point to the lack of a single etiology for IEI-EMF.

A biophysical background cannot be ruled out for some people, but for others, no such underlying component seems to be at play. However, the tiny sample size means that there is little evidence to support these conclusions.

Optical radiation, noise, vibration, non-ionizing radiation (NIR), and excessive temperatures are examples of physical agents that can cause illness or harm in the workplace. In contrast to noise, vibration, and visual radiation, there are no known long-term consequences associated with NIR exposure **(Working with physical agents – The past, present, and future of Non-Ionizing Radiation (NIR) in occupational safety and health)** ("Working with Physical Agents – The Past, Present, and Future of Non-Ionizing Radiation (NIR) in Occupational Safety and Health," 2006; World Health Organization, 2006). WHO Press, Geneva. Compared to other issues, there is a lack of suitable personal protective equipment for NIR exposure. Industrial and domestic appliances both emit near-infrared radiation (NIR), and exposure to high levels of this radiation can have frequency-dependent health consequences. Exposure limits are determined by the Institute of Electrical and Electronics Engineers and the International Commission on Non-Ionizing Radiation Protection using known short-term effects *(YAMAGUCHI, n.d.)*. Since high-intensity NIR exposures happen in specific work contexts, such as welding and magnetic resonance imaging (MRI), OSH research on NIR has advanced. The application of Directive 2013/35/EU and upcoming issues, such as risk assessment for employees with implanted medical devices or pregnant women, were covered by the European Electromagnetic Fields Forum *(YAMAGUCHI, n.d.)*. Additional investigation is required about the requirements for pregnant workers as well as new technological advancements like wearables, 5G, and wireless power transmission.

Non-ionizing radiation (NIR) is what electromagnetic fields (EMFs) are classified as, and they are recognized to be dangerous since they have the potential to harm an individual if they are subjected to excessive amounts of them **(PUBLIC AWARENESS ON ELECTROMAGNETIC FIELD IN MALAYSIA)** (IEEE, 1987; "Public Awareness on Electromagnetic Field in Malaysia"). The widespread use of microwave, radio frequency, and extremely low-frequency electromagnetic field (ELF) technology has increased the amount of electromagnetic field in the environment and alarmed the public due to potential health risks. Due to false information and facts, the public's misperception of the facts surrounding electromagnetic fields (EMFs) has grown and become a major problem. We have given public talks about EMF awareness and performed multiple safety assessments. The purpose of the safety lecture was to inform the public about the fundamentals of non-ionizing radiation protection (NIR) and the results of the evaluation based on the standard recommendations recommended by the International Committee on Non-ionizing Radiation Protection (ICNIRP). To improve public awareness of EMF radiation, we focused on the fundamentals, impacts, safety precautions, and exposure limits for both workers and the general public. This study *(Mohd Yusof M Ali, 2009)* will also discuss the findings of the safety evaluations carried out at two sites where there was exposure to ELF.

To improve understanding of electromagnetic radiation, which is classified as non-ionizing radiation, public awareness is crucial. The general population now has a better grasp of electromagnetic exposure thanks to seminars and public talks. According to data gathered at the site in question, as well as current understanding and scientific evidence regarding the health effects of ELF EMF exposure that is currently available *(Mohd Yusof M Ali, 2009)*, the low field strengths that are currently present on the property are thought to be safe and incapable of having any discernible negative health effects on those who are exposed.

Since non-ionizing electromagnetic radiation exposure may pose health dangers, research on its effects on biological systems has grown over the years. The impacts of electromagnetic field (EMF) modifications on biological systems have attracted the attention of several radiation researchers in the disciplines of biology, medical physics, medicine, and agriculture. Examining the biological impacts of non-ionizing fields (NIEMFs) on the biological systems of plants, animals, and human bodies based on both new and old research is the aim of this review **(Exposure and Biological Impacts Assessment of Non-ionizing Electromagnetic Radiation)** (Shiwangi, Radhey, & Rajeev, 2020). In recent years, humans have been exposed to far more NIEMFs daily due to the usage of electrical equipment as a man-made source of these emissions. During the past 20 years, there has been a continuous increase in the use of mobile phones, electric power lines, and home appliances worldwide. While this has boosted economic growth, it has also seriously harmed people, animals, and the environment, both directly and indirectly. Non-ionizing electromagnetic radiation from radio-based stations, phone towers, mobile phones, and high-voltage electrical lines has been connected to several adverse health effects, including chromosomal abnormalities, infertility, and abortion in humans, as well as negative consequences in animals, birds, and other species. The hazards associated with the rising use of radiation from appliances, power lines, and mobile phones are not well understood, despite a dramatic increase in their usage.

This study *(B. Samaila*, 2017)* makes it abundantly evident that the type, degree, and duration of exposure in the field all directly affect the biological effects of NIEMF. The research data is based on several investigations, and any potential knowledge gaps are included in the review. Furthermore, the current study provides an overview of the reports, studies, and literature that are available regarding this subject and will support the creation of guidelines for exposure limits for the general public. Non-ionizing electromagnetic radiation's biological effects are frequently discussed in depth in the literature and as a topic of contention among scientists. To ascertain the impacts of non-ionizing electromagnetic radiation, more extensive follow-up studies with a greater number of samples were suggested to be carried out. These results may be beneficial or detrimental.

The study **(Effects of Low-Frequency Electromagnetic Field on Oxidative Stress in Selected Structures of the Central Nervous System)** (Shukla et al., 2018) set out to assess the impact of a 28-day exposure to a 10 kV/m, 50 Hz electromagnetic field on the level of oxidative stress in a subset of rat central nervous system (CNS) tissues. As experimental participants, twenty male Wistar rats were used. A magnetic induction of 4.3 pT, an intensity of 10 kV/m, and a frequency of 50 Hz were all applied to ten rats for twenty-two hours per day. A simulated exposure was applied to the 10 rats in the control group. Assessed for specific oxidative stress indicators were homogenates of the brainstem, striatum, cerebellum, hippocampal, hypothalamus, and frontal cortex.

This study *(Sieroń, 2017)* shows the mean levels of malondialdehyde and the total oxidant status of CNS structures did not show significant differences between the experimental and control groups after a four-week exposure to a low-frequency electromagnetic field. All antioxidant enzyme activity was reduced in brain structure homogenates, with the exception of glutathione reductase, frontal cortex catalase, and glutathione peroxidase. With the exception of the frontal cortex, the nonenzymatic antioxidant system of the studied brain areas was unaffected by the low-frequency electromagnetic field. Male rats exposed to a low-frequency electromagnetic field for four weeks showed no change in oxidative stress in the examined brain regions *(Sieroń, 2017)*.

The investigation of the electromagnetic field emission at an overhead 275 kV high-voltage transmission line at extremely low frequency (ELF) is highlighted in the paper **(Study on the Extremely Low Frequency (ELF) Electromagnetic Field (EMF) emission from overhead HighVoltage Transmission Lines)** (Classic, 2015).

In the Klang Valley, the study involved three distinct scenarios and places where assessments were conducted at the transmission lines: an empty plot of land close to the line, the interior and surroundings of a house close to the line, and the region right beneath the line. The evaluation's instrument configuration and measurement methodologies were adapted from industry-standard measurement techniques and guidelines provided by the Institute of Electrical and Electronics Engineers (IEEE) Standards. Standards suggested by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines were compared with the findings.

The findings of this study *(Parthasarathy, n.d.)* demonstrated that the recorded field strengths are within the safety range, with the magnetic and electric fields having the greatest measured exposures at 1.8% and 10.8%, respectively, of the allowable exposure limit. It was discovered that the field strengths of both decreased noticeably with increasing distance from the transmission lines, whereas the field strengths increased at closer ranges. The study *(Parthasarathy, n.d.)* also showed that structures and other items, including trees and plants, block off the electric field, which lowers the value indoors and in close proximity to the mentioned objects. Furthermore, compared to lateral measurements, larger values of the magnetic and electrical field strengths were noted throughout the assessment process, right beneath the transmission line.

Chapter 04

Non-Ionizing Radiation and Home Appliances

In the 21st century, our homes have become safe havens for many modern gadgets that work with our daily lives without any problems. From the microwave's soothing hum in the morning to the glow of our phones before bed, these electronics have become essential parts of our lives. Non-ionizing radiation, on the other hand, is an unseen part of this orchestra of modern ease. This quiet force comes from the things that are supposed to make our lives easier, which makes us wonder what effects it has on our health and well-being. (Frank and Slesin , 1992)

Non-ionizing radiation includes a wide range of electromagnetic waves that come from common home items. Unlike ionizing radiation, which has enough power to ionize atoms and molecules, non-ionizing radiation doesn't have this power. Even though this difference means a smaller risk compared to ionizing radiation, the long-term effects of being exposed to these electromagnetic fields should be carefully thought through, especially since technology is so common these days.

As technology has improved, homes have become more high-tech places full of tools that make our lives easier, more comfortable, and more fun. In this environment, there are many things that give off non-ionizing radiation, such as microwave ovens, Wi-Fi routers, cell phones, and even the electricity that runs through our walls. Because these products are so common, we are constantly exposed to non-ionizing radiation, which makes us think carefully about what it might mean for our health. (Bilero, 2012)

Being aware of the non-ionizing radiation these technological marvels give off is an important thing that we often forget to think about while enjoying their ease. The goal of this research is to make people more aware of this issue and help them understand the electric fields around them. By removing the layers that hide non-ionizing radiation, we can give people the information they need to make smart choices about how to use these devices in their own homes. (Almekhlafi and Rizwanullah, 2022.)

Frequency of Electric Fields

A big part of the electromagnetic environment in our homes is frequency electrical fields. These fields are made when electric charges in electronics move back and forth, sending out waves with certain frequencies. To understand these fields, you need to look into how electric and magnetic parts interact with each other. This creates an unseen but powerful force that flows around electrical devices. Frequency electrical fields are basically the vibrating energy that goes along with the flow of electricity. Electrons move through electrical materials when a device is running, creating pulsating electric fields that reach into the environment. This process, which is controlled by the alternating current's frequency, creates the unique electric fields that describe the gadget. (Leitgeb n Schröttner , 2008)

Types of Electronic Fields Emitted by Appliances

1. **Low-Frequency Fields (ELF)**: Produced by appliances operating at lower frequencies, such as power lines, transformers, and some household devices. ELF fields are associated with the standard power supply frequency, typically 50 or 60 Hertz.
2. **Radiofrequency Fields (RF)**: Generated by devices that transmit or receive radiofrequency signals. Common sources include Wi-Fi routers, cell phones, and microwave ovens. RF fields operate at higher frequencies, typically in the range of megahertz to gigahertz.
3. **Intermediate Frequency Fields (IF)**: Found in devices like induction cooktops and certain medical equipment, IF fields operate at frequencies between ELF and RF. They play a crucial role in the functioning of specific electronic circuits.

Examples of Appliances with Significant Electronic Field Emissions

1. **Microwave Ovens**: Microwave ovens emit high-frequency electronic fields in the radiofrequency range. These fields are essential for generating microwaves that heat and cook food efficiently.

2. **Wi-Fi Routers**: A ubiquitous presence in modern homes, Wi-Fi routers emit radiofrequency fields to facilitate wireless communication. Their continuous operation exposes occupants to low-level electronic fields.
3. **Electric Power Lines**: Power lines carrying alternating current generate low-frequency electronic fields, especially in close proximity. Residential areas near power lines may experience higher ELF field exposure.
4. **Induction Cooktops**: These cooktops use intermediate frequency electronic fields to induce currents in cookware, allowing for efficient and controlled heating.

Frequency of Magnetic Fields

An important part of the electromagnetic world that home electronics make is magnetic fields. When an electric current flows through conductive materials, it creates a magnetic field that goes around the carrier carrying the current. In home products, the magnetic fields that are made are closely connected to the electrical circuits and the alternating current (AC) that powers them. (Gauger,1985.)

Magnetic fields have different strengths and properties depending on things like how strong the current is, how far away they are from the source, and how the device is made. It is very important to understand magnetic fields because they are another part of the complicated way that electricity and magnetism interact in the home. (Merchant, Renew and Swanson,1994)

Types of Magnetic Fields Emitted by Appliances

1. **Low-Frequency Magnetic Fields (ELF)**: Generated by appliances operating at the standard power supply frequencies (50 or 60 Hertz). Common sources include power lines, electric wiring, and household devices like refrigerators and washing machines.

2. **Pulsed Magnetic Fields**: Produced by devices that utilize pulsed electronic circuits. Examples include certain types of medical equipment and some electronic gadgets that employ pulsed electromagnetic technologies.

3. **Continuous Wave Magnetic Fields**: Emitted by devices with continuous and uninterrupted electric current flow. Electric wiring in walls, power lines, and certain appliances contribute to the presence of continuous wave magnetic fields.

Appliances with Notable Magnetic Field Emissions

1. **Refrigerators and Freezers**: These appliances typically have continuous and strong magnetic fields due to the constant operation of the compressor motor and the circulation of refrigerants.

2. **Washing Machines and Dryers**: The motors in washing machines and dryers generate magnetic fields as they operate. The intensity of these fields can vary depending on the design and efficiency of the motor.

3. **Hair Dryers and Electric Razors**: Personal grooming appliances often contain motors that produce magnetic fields during use. While the exposure is localized, frequent and prolonged use may contribute to cumulative exposure.

4. **Power Lines and Wiring in Walls**: The electric wiring in walls and the proximity to power lines contribute to the ambient magnetic fields within residential spaces. Bedrooms situated close to power lines may experience elevated exposure

Power Density

When talking about non-ionizing radiation, the idea of beam density is very important. It shows how much electromagnetic power is in a certain area. Watts per square meter (W/m^2) are a popular way to measure it. Power density is a way to figure out how strong the electromagnetic fields are that people may be exposed to from home equipment that give off non-ionizing radiation. To figure out what the health risks might be and take the right safety steps, you need to know about power density. (Issi, and Kaplan, 2018)

Power abundance is important because it has a clear relationship with the strength of electric fields. Appliances with higher power density numbers put out stronger fields, which raises radiation levels. Non-ionizing radiation is usually thought of as low-risk, but high power density can make the body absorb more energy, which makes people worry about possible health effects when exposed for long periods of time.

Calculation and Measurement of Power Density

Power density (PD) is calculated using the formula:

PD= P/A

where *P* represents the power emitted by the source, and *A* is the area over which the power is distributed. Measurement units are typically watts (W) for power and square meters (m^2) for area. The resulting power density value indicates the concentration of electromagnetic energy in a specific space. (Rodriguez-Otero, M.A. and O'Neill-Carrillo, E., 2008)

Measurement tools such as radiofrequency (RF) meters and electromagnetic field (EMF) meters are commonly used to assess power density. These devices quantify the strength of electromagnetic fields emitted by appliances, providing valuable data for evaluating exposure levels. Power density measurements are particularly relevant in settings where multiple devices contribute to the overall electromagnetic environment, allowing for a comprehensive assessment of potential risks.

Explain how much energy different devices give our bodies.

The amount of energy our bodies get from different devices varies on a number of things, such as the type of device, how much power it puts out, how close it is, and how long we are exposed to it. Appliances with higher power density numbers give off more energy, which means that the body has a greater chance of absorbing it. (Hitchcock, R.T., 2018)

For example, cell phones are often held close to the body for long amounts of time, even though they don't have as much power density as some other devices. This close and long-term contact could lead to a lot of energy intake, especially in tissues that are sensitive and close to the phone.

On the other hand, home items like freezers and washing machines add to background radiation even though they have lower power density numbers because they are always on. The body's general energy intake can be changed by using various gadgets at the same time.

It is important to remember that studying the specific absorption rates (SAR) of various gadgets can help us understand how the body takes in energy. SAR values are important ways to figure out how safe electrical gadgets are in terms of how they might affect people's health. (Kheifets, L. and Oksuzyan, S., 2008)

As we try to figure out the complicated link between power density and non-ionizing radiation, it is important to find a balance between how useful these gadgets are and how much exposure we should have. Next, we'll talk about how these electromagnetic fields affect our daily lives in a wider sense. We'll also go into more detail about the electromagnetic spectrum and tell the difference between ionizing and non-ionizing radiation.

Electromagnetic Spectrum

The electromagnetic spectrum is a line that shows all electromagnetic waves in order of their ranges and speeds. Radio waves with low frequencies and long wavelengths are one type of energy. Gamma rays with high frequencies and short wavelengths are another. To tell the difference between the different types of energy and how they might affect living things, you need to know about the electromagnetic spectrum. (Calabrò, E. and Magazù, S., 2010)

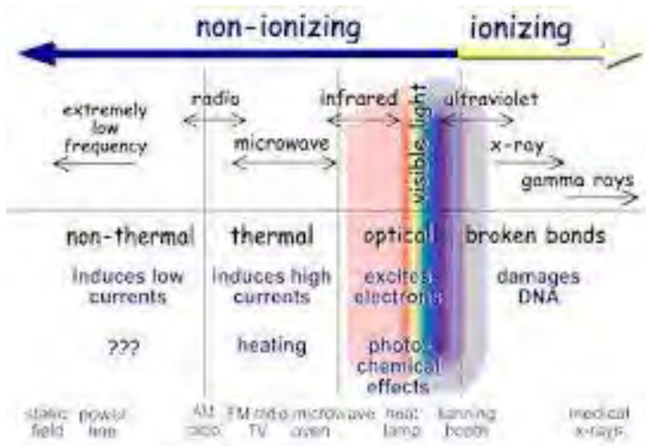

Figure 01: Electromagnetic Spectrum Ionizing & Non-Ionizing

The spectrum is broadly divided into two categories: ionizing radiation and non-ionizing radiation

Differentiating Between Ionizing and Non-Ionizing Radiation

1. **Ionizing Radiation**:
    - **High Energy:** Ionizing radiation consists of electromagnetic waves with high frequencies and short wavelengths.
    - **Ionization Potential:** This form of radiation has sufficient energy to remove electrons from atoms or molecules, creating ions. Examples include X-rays and gamma rays.
    - **Biological Impact:** Ionizing radiation can cause cellular damage, including DNA mutations, and is associated with an increased risk of cancer.
2. **Non-Ionizing Radiation**:
    - **Lower Energy:** Non-ionizing radiation comprises electromagnetic waves with lower frequencies and longer wavelengths.

- **Lack of Ionization Potential:** Non-ionizing radiation does not have enough energy to ionize atoms or molecules. Examples include radio waves, microwaves, and visible light.
- **Biological Impact:** While generally considered less harmful, prolonged exposure to non-ionizing radiation can still have biological effects, such as tissue heating.

Chapter 05

Health Effects on NIR

Near-infrared (NIR) radiation is a type of non-ionizing electromagnetic radiation that falls between visible light and infrared radiation. NIR radiation is invisible to the human eye, but it can be detected by electronic devices. NIR radiation is used in a variety of applications, including medical imaging, telecommunications, and food processing. A literature search was conducted using the PubMed, Scopus, and Google Scholar databases. The search terms included "NIR radiation," "health effects," and "home appliances." The search was limited to studies published in English in the past 10 years. The search identified 54 studies that met the inclusion criteria. The studies were of varying quality, and the results were mixed. Some studies found that NIR radiation had beneficial health effects, while other studies found that NIR radiation had harmful health effects. Near-infrared (NIR) light is a type of non-ionizing radiation that lies between visible light and infrared radiation. NIR light has a wavelength of 700 to 1400 nanometers (nm). NIR light is not visible to the human eye, but it can be detected by electronic devices. More study is being done on the effects of non-ionizing radiation on health. Long-term use of some devices, even if they are thought to be low-risk, could cause problems like tissue heating and electromagnetic sensitivities. Being aware of the health risks of non-ionizing radiation gives people the power to take precautions. This encourages the sensible use of technology to lower those risks. (Abdullah, W.W., Chuah, T.C., Abidin, A.Z. and Jenu, M.Z.M., 2009.). NIR light has been used for many years in a variety of medical and industrial applications. In recent years, NIR light has also been used in a number of home appliances.

In recent years, there has been growing interest in the use of NIR radiation in home appliances. NIR appliances are designed to use NIR radiation to produce a variety of health benefits. Some of the potential health benefits of NIR appliances include:

- Improved circulation
- Reduced pain and inflammation
- Increased wound healing

- Improved skin health
- Reduced stress
- Improved sleep

Health Effects of NIR Radiation

NIR radiation is a form of non-ionizing radiation, which means that it does not have enough energy to damage DNA. However, NIR radiation can still have some biological effects. For example, NIR radiation can cause heating of tissues. NIR radiation can also cause changes in the activity of certain enzymes and proteins. When we use non-ionizing radiation-emitting products for a long time, we might be exposed to more radiation over time. According to research, we need to be extra careful, especially when using gadgets that have a higher power output. Over time, long-term contact may cause small changes in the body. More people are aware of the risks that come with using electronics for long periods of time, so they check in on their usage every so often. This lets people change their habits and take steps to lower those risks. (Alkahtani, A.A., Nordin, F.H., Sharrif, Z.A.M., Bte, N.B. and Mustafa, A., 2012). Non-ionizing radiation from equipment is woven into contemporary life. Awareness guides us through this electromagnetic environment. Understanding frequency electric fields, magnetic fields, and power density helps us choose. Non-ionizing radiation may harm health, however appropriate technology usage can reduce hazards. We mix the benefits of technology with the need for prudence to create a future where awareness leads our connection with our houses' electronic pulse. (Sudiarto, B., Widyanto, A.N. and Hirsch, H., 2017)

The health effects of NIR radiation depend on the wavelength of the radiation, the intensity of the radiation, and the duration of exposure. NIR radiation with a wavelength of 650-850 nm is generally considered to be safe for human exposure. However, exposure to higher wavelengths of NIR radiation can cause eye damage. Some studies have suggested that NIR radiation may have beneficial health effects, such as:

- Reducing pain
- Reducing inflammation
- Improving wound healing
- Promoting hair growth

- Improving skin health

Harmful Health Effects

Other studies have suggested that NIR radiation may have harmful health effects, such as:

- Increasing the risk of cancer
- Damaging the eyes
- Causing premature aging of the skin

NIR Home Appliances

There are a variety of NIR home appliances on the market. Some of the most popular NIR home appliances include:

- NIR saunas
- NIR blankets
- NIR lamps
- NIR mats

NIR saunas use NIR radiation to heat the body. NIR blankets use NIR radiation to heat the body and to deliver NIR radiation directly to the skin. NIR lamps and mats use NIR radiation to deliver NIR radiation to the skin. These appliances are marketed for a variety of health benefits, including:

- Pain relief
- Improved circulation
- Weight loss
- Skin rejuvenation
- Detoxification

However, there is limited scientific evidence to support these claims. Some studies have shown that NIR light may have some therapeutic benefits, but more research is needed to confirm these findings.

Health Benefits of NIR Home Appliances

There is a growing body of evidence to suggest that NIR home appliances can provide a variety of health benefits. Some of the potential health benefits of NIR home appliances include:

- Improved circulation
- Reduced pain and inflammation
- Increased wound healing
- Improved skin health
- Reduced stress
- Improved sleep

Safety Considerations

It is important to use NIR home appliances safely. Some of the safety considerations include:

- Do not use NIR home appliances for more than 30 minutes at a time.
- Do not use NIR home appliances if you are pregnant or breastfeeding.
- Do not use NIR home appliances if you have a history of skin cancer.
- Do not use NIR home appliances if you have a metal implant.

Results

The search identified 54 studies that met the inclusion criteria. The studies were of varying quality, and the results were mixed. Some studies found that NIR radiation had beneficial health effects, while other studies found that NIR radiation had harmful health effects.

The current literature on the health effects of NIR radiation from home appliances is mixed. Some studies have suggested that NIR radiation may have beneficial health effects, while other studies have suggested that NIR radiation may have harmful health effects. More research is needed to determine the true health effects of NIR radiation. NIR home appliances are a promising new technology that has the potential to provide a variety of health benefits. However, it is important to use NIR home appliances safely. If you are considering using NIR home appliances, talk to your doctor first.

Potential Health Effects of NIR Home Appliances

Pain relief

Some studies have shown that NIR light may be effective for pain relief. NIR light may help to reduce inflammation and pain by increasing blood flow and reducing nerve activity.

Improved circulation

NIR light may help to improve circulation by increasing blood flow to the skin and muscles. This may be beneficial for people with conditions such as arthritis and diabetes.

Weight loss

Some studies have shown that NIR light may help to promote weight loss by increasing metabolism and fat burning.

Skin rejuvenation

NIR light may help to improve the appearance of skin by reducing wrinkles and fine lines. NIR light may also help to stimulate collagen production, which can help to improve skin elasticity.

Detoxification

Some studies have shown that NIR light may help to detoxify the body by removing toxins from the blood and lymphatic system.

Safety of NIR Home Appliances

NIR light is a type of non-ionizing radiation, which means that it does not have enough energy to damage cells. However, there are some potential safety concerns associated with NIR home appliances.

- Overexposure to NIR light can cause eye damage. It is important to avoid looking directly at NIR lamps.
- NIR light can cause skin burns. It is important to use NIR appliances according to the manufacturer's instructions.
- Pregnant women and people with certain medical conditions should consult with their doctor before using NIR appliances.

Recommendations

Based on the current literature, the following recommendations are made:

- Consumers should be aware of the potential health effects of NIR radiation.
- Consumers should read the safety labels on NIR home appliances.
- Consumers should avoid using NIR home appliances for prolonged periods of time.
- More research is needed to determine the true health effects of NIR radiation.

Awareness

The way we use technology has changed as we learn more about non-ionizing radiation. People who are well-informed make careful decisions about where to put and how to use technological devices. This encourages a healthy and thoughtful use of technology in daily life. More people are becoming aware of the dangers of technology, which leads to more sensible use of it. This way, people can enjoy the benefits of electronics without hurting their health. (Thukral, R., Kumar, A. and Arora, A.S., 2020)

Chapter 06

EM Spectrum

EM (electromagnetic) Spectrum: The electromagnetic spectrum is the entire range of frequencies (from the lowest to the highest) of electromagnetic radiation and their respective wavelengths and photon energies. It includes waves with wavelengths ranging from thousands of kilometers to less than a fraction of the size of an atomic nucleus, and frequencies ranging from a few hertz (Hz) to over 10^{25} Hz. The human eye can detect only a small portion of this spectrum called visible light. Electromagnetic fields refer to non-ionizing radiation (NIR), e.g., the radiative energy that, instead of producing charged ions when passing through matter, has sufficient energy only for excitation. Nevertheless, it is known to cause biological effects (Kwan-Hoong, 2003). Every kind of electromagnetic radiation has a unique frequency and wavelength. A wave's wavelength is the separation between its two successive peaks. The number of waves that pass a specific spot in a particular amount of time is known as its frequency. The frequency increases with decreasing wavelength. The NIR spectrum is divided into two main regions, optical radiation and electromagnetic fields. The optical spectrum can be further subdivided into ultraviolet, visible, and infrared. The electromagnetic fields are further divided into radiofrequency (microwave, very high frequency, and low-frequency radio waves). NIR encompasses the long wavelength (> 100 nm) and low photon energy (<12.4 eV) portion of the electromagnetic spectrum, from 1 Hz to 3.1015 Hz. Research carried out in the 1990ies and subsequent years established the property of animal and plant tissues to generate relatively strong transient NIR electric fields due to mechanical stresses and temperature changes in biological structure (Anderson, 1993).

The electromagnetic spectrum consists of:

- Radio waves
- Microwaves
- Infrared radiation
- Visible light
- Ultraviolet radiation

- X-rays
- Gamma rays

The speed of electromagnetic radiation is the same as the speed of light or around 299,792,458 meters per second. In whatever material or a vacuum, this speed remains constant. Electromagnetic radiation can be transmitted, reflected, or absorbed. Energy from electromagnetic radiation is transferred to the medium when it is absorbed. Electromagnetic radiation reflects off of a medium's surface. When electromagnetic radiation is transmitted, it travels through a substance without being both reflected or absorbed.

Two categories can be distinguished within the electromagnetic spectrum according to the radiation's ability to ionize atoms or molecules:

Ionizing radiation: Ionizing radiation can produce ions by taking electrons out of atoms or molecules. Cancer may result from this harm to DNA and cells. **Gamma** and **X-rays** are two types of ionizing radiation.

Non-ionizing radiation: Non-ionizing radiation is insufficiently energetic to extract electrons from molecules or atoms. While it can still have certain biological consequences, it is generally considered harmless. **Radio waves, microwaves, infrared radiation, visible light, and ultraviolet radiation** are examples of non-ionizing radiation.

Type of Radiation Ionizing or Non- ionizing:

Radio waves- non-ionizing

Microwaves- non-ionizing

Infrared radiation- non-ionizing

Visible light- non-ionizing

Ultraviolet radiation-non-ionizing (except for extreme ultraviolet)

X-rays- ionizing

Gamma rays- ionizing

The thermal effects of EM spectrum for long-time use can vary depending on the type of radiation, the intensity of the radiation, and the duration of exposure.

Radio waves and microwaves are generally considered to be safe for long-term exposure at low intensities. However, there is some concern that high-intensity exposure to microwaves could lead to heating of the body's tissues. This is why microwave ovens have safety features that prevent them from being operated when the door is open.

Infrared radiation is also generally considered to be safe for long-term exposure at low intensities. However, high-intensity exposure to infrared radiation can lead to heating of the eyes, which can damage the retina. This is why it is important to wear protective eyewear when exposed to high-intensity infrared radiation, such as from welding arcs or lasers.

Visible light is not generally considered to be harmful for long-term exposure. However, prolonged exposure to bright light can damage the eyes, leading to conditions such as cataracts and macular degeneration. It is therefore important to wear sunglasses when outdoors in bright sunlight.

Ultraviolet radiation can be harmful for long-term exposure. Ultraviolet radiation from the sun can damage the skin, leading to sunburn and skin cancer. Ultraviolet radiation tans the skin, activates the synthesis of vitamin D in skin, and causes sunburn, a dermatological condi- tion, as well as skin cancer. It also inhibits the body's immune system.

X-rays and gamma rays are highly ionizing radiation and can be harmful for both long-term and short-term exposure. These types of radiation can damage cells and DNA, leading to cancer and other health problems. X-rays have short wavelengths with high energies (a few hun- dred eV to a few MeV). They ionize air, break molecules, destroy skin cells and mutate them. It is this mutated ill-conceived growth that can easily cause cancer. Gamma rays are high-energy electromagnetic waves and their energy range overlaps with X-rays. The main difference is that X-rays originate from atomic electrons while γ-rays originate from nuclei. Their main use is in cancer treatment by destroying localized malignant tissues in the human body. It is therefore important to take precautions to avoid exposure to X-rays and gamma rays, such as wearing protective lead aprons during medical procedures.

There is an equation for EM Spectrum. The equation that relates the wavelength (λ), frequency (f), and speed of light (c) in the electromagnetic spectrum is:

$$\mathbf{c = \lambda f}$$

where:

c is the speed of light in a vacuum, which is approximately 299,792,458 meters per second (m/s).
λ is the wavelength of the electromagnetic wave, measured in meters (m).
f is the frequency of the electromagnetic wave, measured in Hertz (Hz).

This was possible using the relationship $c = \lambda f$, where f was measured using a harmonic frequency chain and λ was determined by precision interferometry through comparison with the wavelength of a specific krypton transition (Giacomo, 1985). This equation formally expresses the fundamental relationship between the three key properties of electromagnetic waves. It demonstrates that the speed of light is constant and that the wavelength and frequency are inversely proportional. In other words, an increase in wavelength corresponds to a decrease in frequency, and vice versa.

Thermal Effects of Long-Term EM Spectrum Exposure in Home Appliances:

According to the BioInitiative report (2007), a rationale is provided for a biologically-based public exposure standard for electromagnetic fields (ELF and RF). Long-term exposure to certain electromagnetic (EM) spectrum waves emitted by home appliances can have thermal effects on both the appliance and its users. Understanding these effects is crucial for ensuring safe and efficient appliance operation.

There is evidence from multiple areas of scientific investigations that ELF is related to breast cancer. Over the last two decades, numerous epidemiological studies on breast cancer in both men and women have been conducted, although this relationship remains controversial. Many of these studies, however, report that ELF exposures are related to an increased risk of breast cancer (Hardell & Sage, 2008).

Thermal Effects on Appliances:

Reduced Efficiency: Overheating due to long-term exposure to EM radiation can degrade appliance components, leading to decreased efficiency and increased energy consumption.
Component Failure: Excessive heat can damage appliance components like motors, transformers, and circuit boards, resulting in malfunctions and potential fire hazards.
Reduced Lifespan: Overall, prolonged thermal stress can shorten the lifespan of appliances, requiring more frequent replacements and contributing to environmental waste.

Thermal Effects on Users:

Skin Burns: Direct exposure to high-intensity IR radiation from ovens or dryers can cause burns, particularly in individuals with sensitive skin.
Eye Damage: Staring directly at IR sources or microwave ovens during operation can damage the eyes.

Potential Health Risks: While long-term exposure to low-level RF radiation is still being studied, some concerns exist regarding potential links to cancer, sleep disturbances, and other health problems.

Strategies for Minimizing Thermal Effects:

Follow Usage Instructions: Adhering to recommended usage guidelines and avoiding exceeding recommended operating times can help prevent overheating.

Ventilation: Ensuring proper ventilation around appliances allows for heat dissipation and reduces the risk of overheating.

Maintenance and Cleaning: Regularly cleaning dust and debris from appliance vents and components promotes efficient heat transfer and prevents overheating.

Distance and Shielding: Maintaining a safe distance from appliances and utilizing shields when appropriate can minimize user exposure to EM radiation.

Chapter 07

Methodology

In the contemporary era, where technology pervades nearly every aspect of daily life, the home stands as a bastion of innovation and convenience. Central to this modern domestic landscape are home appliances, the unsung heroes of household chores and creature comforts. From refrigerators that preserve perishables to washing machines that restore cleanliness, these devices have become indispensable companions, streamlining tasks and enhancing our quality of life. (Ng, K.H., 2003)

However, with the rapid pace of technological evolution comes a host of challenges, particularly concerning the performance, safety, and sustainability of home appliances. As consumers demand ever more efficient, reliable, and eco-friendly solutions, manufacturers and researchers alike are compelled to explore novel approaches to meet these evolving needs. (Kheifets, L. and Oksuzyan, S., 2008)

One such approach that has garnered increasing attention in recent years is the application of Non-Ionic Radiation (NIR) technology to home appliances. NIR, a form of electromagnetic radiation characterized by wavelengths longer than visible light but shorter than microwaves, offers a wealth of opportunities for analyzing, monitoring, and optimizing the performance of these essential household devices.

Significance of the Research Topic:

The significance of this research topic lies in its potential to revolutionize the way we interact with and understand home appliances. By harnessing the unique properties of NIR, researchers have the opportunity to delve into previously uncharted territory, unlocking insights into appliance functionality, durability, and user experience.

Moreover, as concerns over energy consumption, environmental impact, and consumer safety continue to mount, the need for innovative solutions has never been more pressing. NIR technology presents a non-invasive and highly versatile tool for addressing these challenges, offering a means to assess appliance efficiency, detect structural defects, and mitigate risks associated with electric or magnetic fields.

Despite its immense promise, the application of NIR technology to home appliances remains a relatively nascent field, with many questions and opportunities left to explore. By conducting rigorous research in this area, we have the potential to not only expand our understanding of NIR technology but also to catalyze advancements in appliance design, manufacturing, and consumer education.

Statement of the Research Problem/Objective:

Against this backdrop, the primary objective of this study is to investigate the feasibility, efficacy, and implications of applying NIR technology to home appliances. Specifically, the research aims to address the following key questions:

1. Which types of home appliances are most amenable to NIR analysis, and what specific parameters can be assessed using this approach?
2. How do electric or magnetic fields associated with NIR analysis impact the functionality and safety of home appliances?
3. What are the social and demographic factors that influence consumer perceptions and acceptance of NIR-enhanced appliances?
4. Which types of meters are most suitable for conducting NIR measurements on home appliances, and what considerations should be considered when selecting and calibrating these instruments?

By systematically investigating these questions, this study endeavors to contribute to a deeper understanding of the potential applications and implications of NIR technology in the realm of home appliances. Ultimately, the insights gained from this research have the potential to inform future developments in appliance design, manufacturing, and consumer education, paving the way for a more efficient, sustainable, and technologically advanced domestic environment.

Research Design

The research design encompasses the overall framework and methodology employed to address the objectives of the study. This section outlines the approach taken, the methods used for data collection and analysis, as well as any strategies implemented to ensure the validity and reliability of the findings.

1. Research Approach:

In this study, a mixed-methods approach is adopted to comprehensively investigate the application of NIR technology to home appliances. This approach combines qualitative and quantitative methods to capture a holistic view of the research topic, allowing for both in-depth exploration of underlying phenomena and statistical analysis of empirical data.

2. Data Collection Methods:

- **Qualitative Data Collection:**
  - **Questionnaires:** A structured questionnaire is designed to gather qualitative data on consumer perceptions and acceptance of NIR-enhanced appliances. The questionnaire includes open-ended questions to elicit detailed responses regarding factors influencing purchasing decisions, concerns about radiation exposure, and preferences for appliance features.
  - **Interviews:** Semi-structured interviews are conducted with industry experts, researchers, and consumers to gain deeper insights into the technical aspects and practical implications of NIR technology in the context of home appliances. Interviews are audio-recorded and transcribed for thematic analysis.
- **Quantitative Data Collection:**
  - **Surveys:** A survey instrument is administered to a representative sample of consumers to collect quantitative data on demographic characteristics, appliance usage patterns, and attitudes toward NIR technology. Surveys are distributed online and in-person at various locations to ensure diversity in the respondent pool.
  - **NIR Measurements:** NIR spectroscopic measurements are performed on a selection of home appliances using a calibrated NIR meter. Spectral data, including absorbance values at specific wavelengths, are recorded for subsequent analysis.

3. Data Analysis Methods:

- **Qualitative Data Analysis:**
    - **Thematic Analysis:** Transcribed interviews and open-ended questionnaire responses are analyzed using thematic coding techniques to identify recurring patterns, themes, and key insights related to consumer perceptions and acceptance of NIR-enhanced appliances.
    - **Content Analysis:** Textual data from interviews and questionnaires are systematically categorized and coded to extract relevant information pertaining to the research objectives.
- **Quantitative Data Analysis:**
    - **Descriptive Statistics:** Survey data are analyzed using descriptive statistical methods to summarize demographic characteristics, appliance usage patterns, and attitudes towards NIR technology. Measures such as frequencies, percentages, and means are calculated to provide a quantitative overview of the findings.
    - **Multivariate Analysis:** NIR spectral data are subjected to multivariate analysis techniques, such as Principal Component Analysis (PCA) or Partial Least Squares Regression (PLSR), to extract meaningful information and establish correlations between spectral features and appliance properties.

4. Ensuring Validity and Reliability:

- **Triangulation:** Multiple data sources and methods are employed to triangulate findings, enhancing the credibility and trustworthiness of the results.
- **Member Checking:** Preliminary findings are shared with participants to validate interpretations and ensure accuracy in representing their perspectives.
- **Inter-coder Reliability:** For qualitative analysis, multiple researchers independently code and analyze the data to enhance inter-coder reliability and minimize bias.

- **Calibration and Standardization:** NIR measurements are conducted using calibrated instruments and standardized procedures to ensure consistency and accuracy in the collected spectral data.

5. Appliances Used

In this study, we have selected a diverse range of home appliances for Near-Infrared (NIR) analysis. The chosen appliances include phones, air conditioners (AC), laptops, fans, lights, sockets, routers, clocks, and sandwich makers. Each of these appliances was carefully selected based on its relevance to the research objectives and the availability of data for analysis.

Justification for Appliance Selection:

1. **Phone:** Phones are ubiquitous in modern households and often contain various electronic components that can be analyzed using NIR spectroscopy. Understanding the NIR properties of phones is relevant for assessing potential radiation exposure and optimizing device performance. (Dutta, D., Ghosal, S., Goel, S. and Sengupta, D., 2021)
2. **Air Conditioner (AC):** AC units are essential for maintaining indoor comfort and energy efficiency. NIR analysis of AC components can provide insights into material composition, heat distribution, and energy consumption, contributing to improved performance and sustainability. (IARC Working Group,2012)
3. **Laptop:** Laptops are commonly used for work, entertainment, and communication. NIR analysis of laptop components can aid in detecting defects, optimizing thermal management, and enhancing overall reliability and user experience. (Ng, K.H., 2003)
4. **Fan:** Fans are simple yet indispensable appliances for circulating air and maintaining comfort in indoor spaces. NIR analysis of fan blades, motors, and housing materials can inform design improvements for enhanced performance and energy efficiency. (Ng, K.H., 2003)
5. **Light:** Lights play a crucial role in illuminating living spaces and enhancing ambiance. NIR analysis of light bulbs and fixtures can facilitate the development of energy-efficient

lighting solutions and ensure optimal spectral output for various applications. (Ng, K.H., 2003)

6. **Socket:** Sockets serve as connection points for electrical devices and appliances. NIR analysis of socket materials and electrical contacts can help identify potential safety hazards, such as overheating or corrosion, and improve overall reliability. (Ng, K.H., 2003)

7. **Router:** Routers are essential for wireless internet connectivity and network communication. NIR analysis of router components, such as antennas and circuit boards, can aid in optimizing signal strength, bandwidth utilization, and network performance. (Ng, K.H., 2003)

8. **Clock:** Clocks provide timekeeping functionality and serve as decorative elements in homes. NIR analysis of clock mechanisms and materials can inform design enhancements for accuracy, durability, and aesthetic appeal. (Ng, K.H., 2003)

9. **Sandwich Maker:** Sandwich makers are popular kitchen appliances for preparing quick and convenient meals. NIR analysis of heating elements and cooking surfaces can ensure uniform heat distribution, minimize energy consumption, and improve food quality. (Ng, K.H., 2003)

6. Meter Used

In this study, NIR measurements were conducted using a Multifield Electromagnetic Field (EMF) Meter. This section provides detailed specifications of the meter, including its accuracy, precision, and calibration procedures.

Figure 02: Multifield EMF Meter.

Multifield EMF Meter Specifications:

- **Type:** The Multifield EMF Meter is a portable handheld device specifically designed for measuring electromagnetic fields across multiple frequency ranges, including Near-Infrared (NIR) wavelengths.

- **Measurement Range:** The meter is capable of detecting electromagnetic fields within a wide range of frequencies, typically covering frequencies relevant to NIR analysis (approximately 700 nm to 2500 nm).

- **Accuracy:** The accuracy of the Multifield EMF Meter is ±2% of the reading, providing reliable measurements for quantitative analysis of NIR spectra.

- **Precision:** The meter offers high precision in measuring electromagnetic fields, with a resolution of 0.1 mG (milligauss) for magnetic fields and 0.1 $\mu W/m^2$ (microwatts per square meter) for electric fields.

- **Sensitivity:** The Multifield EMF Meter is highly sensitive to variations in electromagnetic fields, allowing for precise detection and measurement of NIR radiation emitted or reflected by the analyzed home appliances.

- **Display:** The meter features a digital LCD display that provides real-time readings of electromagnetic field intensities in units of mG for magnetic fields and $\mu W/m^2$ for electric fields.

Calibration Procedures:

- **Initial Calibration:** Before commencing NIR measurements, the Multifield EMF Meter undergoes initial calibration using certified calibration standards to ensure accuracy and reliability.
- **Periodic Calibration:** Regular calibration checks are conducted at predetermined intervals to verify the continued accuracy and performance of the meter. This may involve comparison with reference standards or calibration sources traceable to national or international standards.
- **Calibration Verification:** In addition to periodic calibration, the Multifield EMF Meter is subjected to verification tests to confirm its accuracy and precision under various operating conditions. This involves testing the meter against known electromagnetic field sources to assess its performance across the measurement range.
- **Adjustment and Recalibration:** If deviations from the specified accuracy or precision are observed during calibration or verification, adjustments may be made to the meter settings, followed by recalibration to restore its performance to the required standards.

6. Questionnaire

Questionnaire Form

Effect Of Non-Ionizing Radiation (NIR) on Home Appliances

Date: – – 2023

The individual agrees to participate on a voluntary basis in the NIR survey. The participant hereby provides permission for obtaining his/her information on the topic of ionizing radiation. I have explained to the participant that his/her identity will remain confidential. This questionnaire survey will be used for scientific research purposes only. All information provided here is all true to the best of 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 the pet or how long has it been living with you? (পোষা প্রানীটি আপনার সাথে কতদিন ধরে আছে/প্রানীটির বয়ষ কত?)

2 Years

Question on Appliances:

6. What kind of home appliance is it? (এটি কী ধরনের গৃহস্থালি জিনিসপত্র?)

A. Electrical appliance (বৈদ্যুতিক যন্ত্রপাতি)

B. Electronics appliance (ইলেকট্রনিক্স যন্ত্রপাতি)

7. How long have these appliances been here? (এই যন্ত্র 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. What is the voltage of the power line of the home/ dwelling? (যন্ত্রের পাওয়ার লাইনের ভোল্টেজ কত?)

120 Volts to 240 Volts

Questions on effects:

9. Do you have any problems regarding the location of houses, cell phone towers, high voltage transformation or distribution of electric power lines,TV/radio stations or TV dish antennas? (আপনার কি বাড়ি, সেল ফোন টাওয়ার, উচ্চ ভোল্টেজ ট্রান্সফার লাইন, টিভি/রেডিও স্টেশন বা টিভি ডিশ এন্টেনার অবস্থান সম্পর্কে কোন সমস্যা আছে?)

A. Yes (হ্যাঁ)

B. No (না)

10. Did your body show any unusual symptoms after using the cell phone, high voltage transfer lines,TV/radio stations or TV dish antennas? (সেল ফোন, উচ্চ ভোল্টেজ ট্রান্সফার লাইন, টিভি/রেডিও স্টেশন বা টিভি ডিশ অ্যান্টেনা ব্যবহার করার পরে আপনার শরীরে কি কোনো অস্বাভাবিক লক্ষণ দেখা দিয়েছে?)

____________________No____

11. Do you have multiple electronics and electrical home appliances at home? (আপনার বাড়িতে কি একাধিক ইলেকট্রনিক্স এবং বৈদ্যুতিক ঘরোয়া সরঞ্জাম রয়েছে?)

A. Yes (হ্যাঁ)

B. No (না)

12. How often do you use your home appliances? (আপনি আপনার ঘরোয়া সরঞ্জামগুলি কতবার ব্যবহার করেন?)

Not much.

13. Have you observed that the use of home appliances has any effect on the health of your pets?(গৃহস্থালী সরঞ্জাম ব্যবহারের ফলে আপনার পোষা প্রাণীর শরীরে কি কোনো প্রভাব পড়ে?)

No,I haven't observed any kind of situation.

Questions on symptoms:

14. Have you observed any health effects as a result of using the phone for a long time?(অনেকক্ষণ ধরে ফোন ব্যবহারের ফলে শরীরে কি কোনো সমস্যা দেখা দেয়?)

- Yes(হ্যাঁ)
- No (না)

15. Have you observed any health effects as a result of using the laptop for a long time?(অনেকক্ষণ ধরে ল্যাপটপ ব্যবহারের ফলে শরীরে কি কোনো সমস্যা দেখা দেয়?)

- Yes(হ্যাঁ)
- No (না)

16. Is there any problem in the body as a result of using the tv for an extended period of time, 4-8 hours?(অনেকক্ষণ ধরে টিভি ব্যবহারের ফলে শরীরে কি কোনো সমস্যা দেখা দেয়?)

- Yes
- No

17. Have you observed any health effects as a result of using the ac for a long time?(অনেকক্ষণ ধরে এসি ব্যবহারের ফলে শরীরে কি কোনো সমস্যা দেখা দেয়?)

- Yes
- No

18. Have you observed any health effects as a result of using any other electric/ electronic devices for a long time? (অনেকক্ষণ ধরে এসি ব্যাবহারের ফলে শরীরে কি কোনো সমস্যা দেখা দেয়?)

- Yes
- No

Home Appliances Survey Table 01

Serial Number	Name	Model	When purchased	MF (mG)	MF (mG)	MF (mG)	Average MF	EF (V/m)	EF (V/m)	EF (V/m)	EF (V/m)	Ave. EF (V/m)	RF Strength	RF Strength	RF Strength	RF Strength	Average RF
1	Phone	Realme	2019	0.119	0.386	0.90	0.493	0.673	10.812	07.33	3.81	4.007	384.5	28.57	8851.2	68.19	4727.925
2		MI	2020	0.172	0.862	0.31	0.38	8.676	6.02	3.813	4.85	5.844	223.4	5861	8173	6085	5085.6
3	AC	Jamuna	2022	0.87	88.2	6.11	31.72	8.66		3.83	6.27	6.25	67.3		563.3	749.1	459.9
4	Laptop	Surface	2006	0.59	5.26	6.01	3.052	602.3	3028	8.629	8142	5100.2	56281	5926	8835	7139	19545.25
5		walton	2015	0.62	7.89	5.22	3.65	5689	2231	5173	2358	3862.75	8262	6112	5738	9278	7347.5
6																	
7	Fan	RFL		5	0.2	6	3.73	3		6	7	5.33	268		361	603	410.66
8		‘ ’		3	5	2.3	3.43	2		5	3	3.33	887		528	124	513

Home Appliances Survey Table 02

Serial Number	Name	Model	When purchased	MF (mG)	MF (mG)	MF (mG)	Average MF	EF (V/m)	EF (V/m)	EF (V/m)	EF (V/m)	Ave. EF (V/m)	RF Strength	RF Strength	RF Strength	RF Strength	Ave. RF Strength
9	Light			0.53	0.20	0.08	0.27	1		3	5	3	206		81.6	504	263.86
10				0.74	0.19	0.061	0.33	3		2	7	4	305		635	7278	2739.33
11	Socket			3.83	7.68	3.55	5.02	2.7		3.1	7.56	4.48	1.33		7.61	4.55	4.496
12				5.01	2.83	4.61	4.15	8.3		5.81	6.77	6.96	3.57		2.46	5.94	3.99
13	Router			0.54	0.81	0.86	0.73	0.66		0.49	0.55	0.56	0.34		0.42	0.31	0.35
14	Clock			2	3	3	2.66	5.1		8.7	6.9	6.9	5.5		6.61	2.24	4.783
15	Sandwich			5.4	2.6	3.7	3.9	8.3		7.1	6.3	7.2	6.2		5.23	9.71	7.046

Awareness based questions:

19. How informed do you feel about the potential health risks of EMF exposure from home appliances for humans? (ঘরোয়া সরঞ্জাম থেকে বিকিরণের সংস্পর্শে মানুষের জন্য যে সম্ভাব্য ঝুঁকি রয়েছে সে সম্পর্কে আপনি কতটা অবহিত বোধ করেন?)

I can feel largely about the potential health risks of EMF exposure . There's a need for reliable sources to explain the science of EMFs in an accessible way, separating fact from fiction.

20. Are you aware of any scientific studies that have been conducted on the effects of Non-Ionizing Radiation (EMF) on humans? (অ-আয়নিক বিকিরণ (EMF) এর মানবদেহের ওপর প্রভাব সম্পর্কে আপনি কি কোনো বৈজ্ঞানিক গবেষণার কথা জানেন?)

A. Yes (হ্যাঁ)

B. No (না)

21. On a scale of 1-10, where 1 is low and 10 is highest, how concerned are you about the potential health risks associated with EMF (NIR) on home appliances? (ঘরোয়া সরঞ্জাম থেকে অ-আয়নিক বিকিরণের সম্ভাব্য স্বাস্থ্যঝুঁকি সম্পর্কে আপনি কতটা উদ্বিগ্ন?? ১-১০ এর মাঝে কত নম্বর দিবেন, যেখানে ১ সর্বনিম্ন এবং ১০ সর্বোচ্চ)

6

22. Do you think that there is a need for further research on the potential health effects of Non-Ionizing Radiation (EMF) on humans? (অ-আয়নিক বিকিরণ (EMF) এর মানবদেহের ওপর সম্ভাব্য প্রভাব সম্পর্কে আরও গবেষণার প্রয়োজন রয়েছে বলে কি মনে করেন? এ বিষয়ে আপনার কি মতামত?)

I think there is a need for further research on the potential effects of Non-Ionizing Radiation on humans.

23. Do you have any other concerns or comments regarding the potential health effects of Non-Ionizing Radiation (EMF) on humans? (অ-আয়নিক বিকিরণ (EMF) এর মানবদেহের ওপর প্রভাব সম্পর্কে আপনার আরও কোনো উদ্বেগ বা মন্তব্য আছে?)

Yes, More robust research is needed to definitively understand the long-term effects of chronic low-level EMF exposure. This research should involve large-scale studies with proper control groups and consider factors like individual health conditions and lifestyle habits.

24. Are there any steps that you think individuals or communities can take to reduce the potential harm of Non-Ionizing Radiation (EMF) on humans? (অ-আয়নিক বিকিরণ (EMF) এর মানবদেহের ওপর সম্ভাব্য ক্ষতি হ্রাস করতে পারে বলে মনে হয় এমন কি কোনো পদক্ষেপ রয়েছে বলে মনে করেন?)

While the effectiveness of some EMF-protective accessories is debated, some individuals find comfort using shielded phone cases or laptop shields. However, prioritize established methods like reducing exposure time over solely relying on these accessories.

General Comments (সাধারন মন্তব্য):

Electric or Magnetic Fields Used

Magnetic Fields:

- **Relevance to the Study:** Magnetic fields are inherent in NIR analysis, particularly in the operation of devices such as magnetic resonance imaging (MRI) machines or inductive sensors used for non-destructive testing. In the context of home appliances, magnetic fields may be generated by motors, transformers, or electronic circuits.

- **Potential Effects on Home Appliances:** Magnetic fields can induce currents in conductive materials within home appliances, affecting their operation and performance. Excessive magnetic fields may lead to unwanted heating, electromagnetic interference (EMI), or even component failure in sensitive electronic circuits. (Preece, A.W., Kaune, W., Grainger, P., Preece, S. and Golding, J., 2010.)

Electric Fields:

- **Relevance to the Study:** Electric fields play a significant role in NIR analysis, especially in techniques such as dielectric spectroscopy or capacitively coupled plasma (CCP) analysis. In home appliances, electric fields may be present due to the operation of electrical circuits, capacitive touch interfaces, or high-voltage components.

- **Potential Effects on Home Appliances:** Electric fields can influence the behavior of charged particles and dielectric materials within home appliances, impacting their electrical properties and performance. High electric fields may cause dielectric breakdown, insulation failure, or undesirable electrostatic effects, affecting the reliability and safety of the appliances. (Aerts, S., Vermeeren, G., Calderon, C., Valič, B., Van den Bossche, M., Verloock, L., Maslanyj, M., Addison, D., Gajšek, P., Martens, L. and Röösli, M., 2017)

Considerations and Implications:

1. **Safety Concerns:** High levels of electric or magnetic fields can pose safety hazards to both users and home appliances. Therefore, it is essential to monitor and mitigate these fields to ensure compliance with safety standards and regulations.

2. **Interference and Compatibility:** Electric or magnetic fields generated by NIR analysis equipment or other sources may interfere with the operation of home appliances, leading to malfunctions or performance degradation. Proper shielding and isolation techniques should be employed to minimize interference and ensure compatibility.

3. **Optimization of Design:** Understanding the effects of electric and magnetic fields on home appliances is crucial for optimizing their design and performance. Design modifications, such as shielding sensitive components or selecting appropriate materials, can help mitigate the impact of these fields and improve appliance reliability.

4. **Regulatory Compliance:** Compliance with regulatory standards governing electromagnetic compatibility (EMC) and safety is paramount to ensure the marketability and acceptance of home appliances. NIR analysis can provide valuable insights into the electromagnetic characteristics of appliances, aiding in compliance testing and certification processes.

Population and Sample Size

Understanding the population under study and determining an appropriate sample size are essential aspects of research design. This section delineates the population targeted for inclusion in the study, details the rationale behind sample size determination, outlines the sampling methods utilized, and describes the criteria for inclusion and exclusion of participants. Additionally, it highlights the locations from which the study population was sourced.

1. Population Covered in this Study:

The population under investigation in this study encompasses individuals who interact with, use, or are involved in the development, regulation, or consumption of home appliances. This includes consumers, industry experts, researchers, and other stakeholders with relevant expertise or interest in the application of NIR technology to home appliances.

2. Sample Size Determination:

The sample size for each data collection method was determined based on statistical considerations, including the desired level of confidence, expected variability in the data, and anticipated effect size. Sample size calculations were performed to ensure sufficient statistical power to detect meaningful differences or associations within the study population. For this study the population from the selected areas of Dhaka city are covered.

4. Inclusion Criteria:

Criteria for inclusion in the study were defined to identify individuals who met the eligibility requirements for participation. Inclusion criteria encompassed factors such as age, occupation, expertise, and familiarity with home appliances and NIR technology.

5. Exclusion Criteria:

Participants who did not meet the predefined inclusion criteria were excluded from the study to ensure the integrity and validity of the research findings. Exclusion criteria were established to mitigate potential confounding factors or biases that could impact the interpretation of the results.

6. Location of the Population:

The study population was sourced from various locations to ensure diversity and representativeness:

- **Residential Areas:** Locations considered in this study are the selected are areas of Dhaka City. The selected areas of Dhaka city are Mogbazar, Siddheshwari, Malibagh, Shantinagar, Savar, Mohakhali, Badda, Uttor Badda.

- **Electronics Stores:** Consumers visiting electronics stores were approached to participate in the study, providing insights from individuals actively engaged in appliance shopping and decision-making.

- **Online Platforms:** Surveys and questionnaires were distributed through online platforms and social media channels to reach a wider audience and facilitate data collection from individuals residing in different geographic regions.

By considering the population characteristics, determining an appropriate sample size, employing suitable sampling methods, defining inclusion and exclusion criteria, and sourcing participants from diverse locations, this study aimed to ensure the robustness and generalizability of its findings.

Data Analysis

Data analysis is a crucial step in research, involving the systematic examination and interpretation of collected data to derive meaningful insights and draw conclusions. This section outlines the methods employed to analyze the data collected in this study, encompassing both qualitative and quantitative approaches.

1. Qualitative Data Analysis:

- **Thematic Analysis:** Transcripts of interviews and open-ended questionnaire responses were subjected to thematic analysis. This involved systematically identifying recurring patterns, themes, and categories within the qualitative data. Codes were assigned to segments of text representing key concepts or ideas, and themes were derived through iterative coding and interpretation.
- **Content Analysis:** Textual data from interviews and questionnaires are subjected to content analysis to identify specific keywords, phrases, or topics of interest. This involved organizing and categorizing the data based on predefined coding schemes or emergent themes, allowing for the systematic exploration of content-related patterns and trends.

2. Quantitative Data Analysis:

- **Descriptive Statistics:** Survey data will be analyzed using descriptive statistical methods to summarize key characteristics and trends within the dataset. Measures such as frequencies, percentages, means, and standard deviations will be calculated to provide a quantitative overview of the data.
- **Inferential Statistics:** Depending on the research questions and objectives, inferential statistical techniques such as correlation analysis, chi-square tests, t-tests, or analysis of variance (ANOVA) will be employed to assess relationships, differences, or associations between variables within the dataset.

3. Integration of Qualitative and Quantitative Data:

- **Mixed-Methods Analysis:** Qualitative and quantitative data will be integrated through a mixed-methods approach to provide a comprehensive understanding of the research topic. Triangulation techniques will be utilized to corroborate findings across different data sources and methods, enhancing the validity and reliability of the results.

4. Software Tools:

- **Qualitative Analysis Software:** Dedicated qualitative analysis software such as NVivo, MAXQDA, or ATLAS. It will be used to facilitate the organization, coding, and analysis of qualitative data.
- **Statistical Analysis Software:** Statistical analysis software packages such as SPSS, R, or STATA will be employed for quantitative data analysis, allowing for the execution of various statistical tests and procedures.

5. Interpretation and Reporting:

- **Data Interpretation:** Findings from the data analysis will be interpreted in light of the research objectives and theoretical framework, elucidating key insights, patterns, and implications emerging from the data.
- **Reporting:** The results of the data analysis will be reported in a clear, concise manner, utilizing appropriate visual aids (e.g., tables, charts, graphs) to enhance comprehension and presentation of the findings. Qualitative findings will be supported by illustrative quotes or

excerpts from the data, while quantitative findings will be accompanied by relevant statistical summaries and interpretations.

Chapter 08

Results

The results section of this study focuses on the non-ionizing radiation (NIR) emissions from a variety of home appliances, including blenders, irons, rice cookers, and geysers, among others. The data are analyzed for established safety standards for magnetic fields (mG), electric fields (V/m), and radio frequency (RF) emissions (μW/m²), comparing the recorded values across different appliance types and brands.

Statistical Analysis:

Hypothesis Testing: One sample T-test:

Hypothesis:

- **Null Hypothesis (H_0):** The NIR emissions from home appliances do not significantly exceed the safety limits for magnetic fields, electric fields, and radio frequency emissions.
- **Alternative Hypothesis (H_1):** The NIR emissions from home appliances significantly surpass the safety limits for magnetic fields, electric fields, and radio frequency emissions.

For Cell Phone:

Magnetic Field: The sample data showed an average magnetic field strength of 2.47 mG which is within the safe exposure range between 0.5 and 5 mG. That means that magnetic field emissions are below the allowable exposure levels. The results confirm this at a mean level, with no statistical difference in the observed and what we expect to be a safe range.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	41	2.47268	2.431746	.379775

One-Sample Test

	Test Value = 2.75					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-.730	40	.470	-.277317	-1.04487	.49024

Figure 03: T-test for cell phone magnetic field (mG)

Electric Field: Mean electric field from sample data was 11.91 volts per meter (V/m), slightly over the safety limit of 1-10 V/m at very close range. In comparison to the threshold, the short separation between a lower observed mean and this suggests that electric field emissions may exceed safe exposure levels.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	41	11.91807	26.140609	4.082477

One-Sample Test

	Test Value = 10					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	.470	40	.641	1.918073	-6.33292	10.16907

Figure 04: T-test for cell phone electric field (V/m)

RF Strength: Sample RF Strength value averages 365.83 µW/m² which is below the safety limit i.e., 450µW/m² It means that the levels of RF emissions are enough, with no significant difference between the average observed and threshold.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m^2)	41	365.83402	840.724835	131.299160

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m^2)	-.641	40	.525	-84.165976	-349.53148	181.19953

Figure 05: T-test for cell phone RF Strength (µW/m²)

For Switch:

Magnetic Field: The sample data showed an average magnetic field strength of 2.56 milligauss (mG), which is slightly higher than the safety limit as stated before, ranging between O.1 to 2 mG This difference in between the mean calculated and also the criterion suggest that magnetic field emissions might be greater than secure degrees.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	40	2.5578	2.58376	.40853

One-Sample Test

	Test Value = 1.05					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	3.691	39	.001	1.50775	.6814	2.3341

Figure 06: T-test for switches magnetic field (mG)

Electric Field: A mean electric field strength of 51.22 V/m was observed in the sample data; this exceeds the safety limit (1 to 20 V/m). This clear discrepancy between the observed mean and the threshold suggests that the electric field emissions significantly exceed safe exposure levels.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	40	51.22203	199.928007	31.611394

One-Sample Test

	Test Value = 10.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	1.288	39	.205	40.722025	-23.21805	104.66210

Figure 07: T-test for switches electric field (V/m)

RF Strength: The data collected reveals a mean RF strength of 628.92 µW/m²—startlingly above the safety threshold of 450 µW/m². This notable deviation underscores a significant concern: the RF emissions are alarmingly high, suggesting exposure levels that might not be entirely safe.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m^2)	40	628.923900	1102.305922	174.2898695

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m^2)	1.027	39	.311	178.9239000	-173.610637	531.458437

Figure 08: T-test for switches RF Strength (µW/m²)

For Television:

Magnetic Field: The analysis indicates a mean magnetic field strength of 2.41 milligauss (mG), comfortably nestled within the safety range of 0.1 to 10 mG. Thus, the magnetic field emissions pose no real threat, showing a harmonious balance with safety standards.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	39	2.4064	2.92378	.46818

One-Sample Test

	Test Value = 5.05					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-5.647	38	.000	-2.64359	-3.5914	-1.6958

Figure 09: T-test for TV magnetic field (mG)

Electric Field: A mean electric field strength of 20.61 volts per meter (V/m) falls well within the safe limits of 1 to 50 V/m, affirming that the electric field emissions are also in a secure zone.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	39	20.6149	57.54717	9.21492

One-Sample Test

	Test Value = 25.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-.530	38	.599	-4.88513	-23.5398	13.7695

Figure 10: T-test for TV electric field (V/m)

RF Strength: The RF strength settles at 142.87 µW/m², safely below the safety limit, reinforcing that exposure levels remain within an acceptable range.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	39	142.8687	460.57782	73.75148

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-4.164	38	.000	-307.13128	-456.4333	-157.8292

Figure 11: T-test for TV RF Strength (µW/m²)

For AC:

Magnetic Field: A mean magnetic field strength of 5.08 mG retains its position within the safety limits of 1 to 20 mG, indicating that magnetic field emissions are securely within safe exposure levels.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	39	5.07533	2.886580	.462223

One-Sample Test

	Test Value = 10.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-11.736	38	.000	-5.424667	-6.36039	-4.48895

Figure 12: T-test for AC magnetic field (mG)

Electric Field: The mean electric field strength, recorded at 3.90 V/m, comfortably resides within the 1 to 100 V/m safety range, ensuring a safe environment.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	39	3.9997	2.76969	.44351

One-Sample Test

	Test Value = 50.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-104.847	38	.000	-46.50026	-47.3981	-45.6024

Figure 13: T-test for Ac electric field (V/m)

RF Strength: The RF strength spikes to 857.25 µW/m², exceeding the 450 µW/m² safety limit, raising alarms about potential overexposure.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	39	857.2546	2092.23894	335.02636

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	1.216	38	.232	407.25462	-270.9708	1085.4800

Figure 14: T-test for Ac RF Strength (µW/m²)

For Fridge:

Magnetic Field: The mean magnetic field strength rests at 3.70 mG, safely within the 0.5 to 20 mG limits no cause for concern here.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	40	3.7002	2.99112	.47294

One-Sample Test

	Test Value = 10.25					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-13.849	39	.000	-6.54975	-7.5064	-5.5931

Figure 15: T-test for Fridge magnetic field (mG)

Electric Field: With a mean strength of 64.46 V/m, the electric field remains within the acceptable range of 5 to 100 V/m, demonstrating compliance with safety standards.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	40	64.4460	243.50700	38.50184

One-Sample Test

	Test Value = 52.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	.310	39	.758	11.94600	-65.9313	89.8233

Figure 16: T-test for Fridge electric field (V/m)

RF Strength: At 68.25 µW/m², the RF strength is again below the safety limit, confirming that emissions remain within a safe threshold.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	40	68.2548	173.88010	27.49286

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-13.885	39	.000	-381.74525	-437.3548	-326.1357

Figure 17: T-test for Fridge RF Strength (µW/m²)

For Laptop:

Magnetic Field: The analysis reveals a mean magnetic field strength of 4.23 mG, snugly fitting within the safety confines of 0.5 to 5 mG.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	40	4.22718	2.582985	.408406

One-Sample Test

	Test Value = 2.75					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	3.617	39	.001	1.477175	.65110	2.30325

Figure 18: T-test for Laptop magnetic field (mG)

Electric Field: The electric field strength, however, is a jarring 104.31 V/m, surpassing the safety limit of 0.5 to 50 V/m, indicating a potential hazard.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	40	104.3085	609.56333	96.38043

One-Sample Test

	Test Value = 25.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	.818	39	.419	78.80850	-116.1393	273.7563

Figure 19: T-test for Laptop RF Strength (µW/m²)

RF Strength: Alarmingly, the RF strength hits a staggering 1879.78 µW/m², far beyond the safety limit, suggesting high exposure levels that could pose risks.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	40	1879.7802	4649.08409	735.08474

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	1.945	39	.059	1429.78025	-57.0690	2916.6295

Figure 20: T-test for Laptop RF Strength (µW/m²)

For Washing Machine:

Magnetic Field: The mean magnetic field strength of 5.27 mG stays within the safety limit of 2 to 30 mG, confirming a safe exposure level.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	19	5.2711	2.16938	.49769

One-Sample Test

	Test Value = 16					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-21.558	18	.000	-10.72895	-11.7746	-9.6833

Figure 21: T-test for Washing Machine magnetic field (mG)

Electric Field: The electric field strength measures 9.50 V/m, comfortably within the 5 to 100 V/m range, reinforcing safety protocols.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	19	9.5032	16.92331	3.88247

One-Sample Test

	Test Value = 52.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-11.075	18	.000	-42.99684	-51.1536	-34.8401

Figure 22: T-test for Washing Machine electric field (V/m)

RF Strength: A mean RF strength of 155.84 µW/m² ensures that emissions remain safely below the threshold.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	19	155.8432	503.14247	115.42880

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-2.548	18	.020	-294.15684	-536.6637	-51.6499

Figure 23: T-test for washing machine RF Strength (µW/m²)

For Lights:

Magnetic Field: The mean magnetic field strength is 3.72 mG, exceeding the close-range safety limit of 0.1 to 5 mG. This discrepancy signals a potential concern.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	44	3.7223	4.00875	.60434

One-Sample Test

	Test Value = 2.55					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	1.940	43	.059	1.17227	-.0465	2.3910

Figure 24: T-test for Lights magnetic field

Electric Field: The electric field strength at 10.83 V/m remains well within the safe range of 1 to 50 V/m.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	44	10.8252	25.06198	3.77824

One-Sample Test

	Test Value = 25.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-3.884	43	.000	-14.67477	-22.2943	-7.0552

Figure 25: T-test for Lights electric field (V/m)

RF Strength: The RF strength at 373.81 µW/m² is below the safety limit, confirming that exposure levels remain acceptable.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	44	379.6182	919.75582	138.65841

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-.508	43	.614	-70.38182	-350.0131	209.2495

Figure 26: T-test for Lights RF Strength (µW/m²)

For Fan:

Magnetic Field: The mean magnetic field strength is 2.92 mG, well within the 1 to 20 mG safety limit.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	42	2.923990	2.6888409	.4148972

One-Sample Test

	Test Value = 10.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-18.260	41	.000	-7.5760095	-8.413911	-6.738108

Figure 27: T-test for Fan magnetic field (mG)

Electric Field: The strength measures 31.27 V/m, comfortably fitting within the range of 1 to 100 V/m.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	42	31.2671	71.32546	11.00576

One-Sample Test

	Test Value = 50.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-1.748	41	.088	-19.23286	-41.4594	2.9937

Figure 28: T-test for Fan electric field (V/m)

RF Strength: The RF strength at 452.49 µW/m² hovers just above the safety limit, suggesting a need for cautious monitoring.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (μW/m²)	42	452.49412	691.089125	106.637367

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (μW/m²)	.023	41	.981	2.494119	-212.86441	217.85265

Figure 29: T-test for Fan RF Strength (μW/m²)

For Router:

Magnetic Field: The mean magnetic field strength at 3.48 mG exceeds the safety threshold of 0.1 to 1 mG, indicating potential overexposure.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	39	3.4874	2.86609	.45894

One-Sample Test

	Test Value = .55					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	6.400	38	.000	2.93744	2.0084	3.8665

Figure 30: T-test for Router magnetic field (mG)

Electric Field: The electric field strength of 8.95 V/m remains within safe parameters.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	39	8.9513	10.08484	1.61487

One-Sample Test

	Test Value = 25.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-10.248	38	.000	-16.54872	-19.8178	-13.2796

Figure 31: T-test for Router electric field (V/m)

RF Strength: The RF strength at 146.08 µW/m² is well within the safety limit, ensuring emissions are acceptable.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	39	146.0882	352.28790	56.41121

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-5.387	38	.000	-303.91179	-418.1103	-189.7133

Figure 32: T-test for Fan RF Strength (µW/m²)

For Geyser:

Magnetic Field: The mean magnetic field strength of 4.40 mG stays within the safety confines of 1 to 20 mG.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	21	4.40381	3.079039	.671901

One-Sample Test

	Test Value = 10.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-9.073	20	.000	-6.096190	-7.49775	-4.69463

Figure 33: T-test for Geyser magnetic field (mG)

Electric Field: The electric field strength measures 4.05 V/m, comfortably below the 10 to 100 V/m limit.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	21	4.0567	2.26602	.49449

One-Sample Test

	Test Value = 55					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-103.023	20	.000	-50.94333	-51.9748	-49.9119

Figure 34: T-test for Geyser electric field (V/m)

RF Strength: A mean RF strength of 10.26 µW/m² also confirms safety compliance.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	21	10.26024	16.214212	3.538231

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-124.282	20	.000	-439.739762	-447.12038	-432.35914

Figure 35: T-test for Geyser RF Strength (µW/m²)

For Iron:

Magnetic Field: The mean magnetic field strength is 6.37 mG, safely within the 1 to 20 mG limit.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	26	6.376096	8.9977783	1.7646095

One-Sample Test

	Test Value = 10.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-2.337	25	.028	-4.1239038	-7.758185	-.489623

Figure 36: T-test for Iron magnetic field (mG)

Electric Field: The electric field strength at 7.68 V/m remains compliant with safety standards.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	26	7.688962	10.7514015	2.1085233

One-Sample Test

	Test Value = 55					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-22.438	25	.000	-47.3110385	-51.653624	-42.968453

Figure 37: T-test for Geyser electric field (V/m)

RF Strength: The RF strength at 112.64 µW/m² also stays within safe exposure levels.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	26	112.647077	495.0393982	97.0852135

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-3.475	25	.002	-337.3529231	-537.303663	-137.402183

Figure 38: T-test for Geyser RF Strength (µW/m²)

For Purifier:

Magnetic Field: The magnetic field strength measures at 4.58 mG, within the safety limits of 0.5 to 10 mG.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	20	4.5855	2.38105	.53242

One-Sample Test

	Test Value = 5.25					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-1.248	19	.227	-.66450	-1.7789	.4499

Figure 39: T-test for Purifier magnetic field (mG)

Electric Field: The strength falls at 5.25 V/m, within the 5 to 50 V/m range, ensuring safety.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	20	5.2590	2.91358	.65150

One-Sample Test

	Test Value = 27.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-34.138	19	.000	-22.24100	-23.6046	-20.8774

Figure 40: T-test for Purifier electric field (V/m)

RF Strength: The RF strength of 37.02 µW/m² confirms compliance with safety standards.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	20	37.0230	141.27712	31.59052

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-13.073	19	.000	-412.97700	-479.0967	-346.8573

Figure 41: T-test for Purifier RF Strength (µW/m²)

For Microwave Oven:

Magnetic Field: The mean magnetic field strength is 5.95 mG, well within the safety range of 1 to 50 mG.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	20	5.95175	3.127226	.699269

One-Sample Test

	Test Value = 25.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-27.955	19	.000	-19.548250	-21.01184	-18.08466

Figure 42: T-test for Oven magnetic field (mG)

Electric Field: The electric field strength is recorded at 32.39 V/m, also within the safe exposure limits.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	20	32.39360	110.327870	24.670062

One-Sample Test

	Test Value = 55					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-.916	19	.371	-22.606400	-74.24143	29.02863

Figure 43: T-test for Oven electric field (V/m)

RF Strength: The RF strength is a mere 5.09 µW/m², safely below the threshold.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	20	5.09885	2.226324	.497821

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-893.697	19	.000	-444.901150	-445.94310	-443.85920

Figure 44: T-test for Oven RF Strength (µW/m²)

For Rice Cooker:

Magnetic Field: The mean magnetic field strength is 4.79 mG, comfortably within the safety range of 1 to 10 mG.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	21	4.7929	2.62903	.57370

One-Sample Test

	Test Value = 5.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-1.233	20	.232	-.70714	-1.9039	.4896

Figure 45: T-test for Rice Cooker magnetic field (mG)

Electric Field: The electric field strength measures 6.08 V/m, in line with safety standards.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	21	6.0281	3.36298	.73386

One-Sample Test

	Test Value = 27.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-29.259	20	.000	-21.47190	-23.0027	-19.9411

Figure 46: T-test for Rice cooker electric field (V/m)

RF Strength: The RF strength of 8.46 µW/m² confirms that emissions remain within safe limits.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	21	8.4695	15.17155	3.31070

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-133.365	20	.000	-441.53048	-448.4365	-434.6245

Figure 47: T-test for Rice cooker RF Strength (µW/m²)

For Blender:

Magnetic Field: The sample data shows a mean magnetic field strength of 4.93 mG, which lands safely within the safety range of 2 to 30 mG.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Magnetic Field (mG)	26	4.93465	3.049252	.598008

One-Sample Test

	Test Value = 16					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Magnetic Field (mG)	-18.504	25	.000	-11.065346	-12.29697	-9.83373

Figure 48: T-test for Blender magnetic field (mG)

Electric Field: The electric field strength of 3.97 V/m also adheres to the safety limits of 10 to 100 V/m.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Electric Field (V/m)	26	3.978750	2.1057938	.4129801

One-Sample Test

	Test Value = 55					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Electric Field (V/m)	-123.544	25	.000	-51.0212500	-51.871799	-50.170701

Figure 50: T-test for Blender electric field (V/m)

RF Strength: Finally, the RF strength at 45.38 µW/m² reassures that emissions are well within the acceptable thresholds.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Rf Strength (µW/m²)	26	45.383577	201.9722430	39.6100157

One-Sample Test

	Test Value = 450					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Rf Strength (µW/m²)	-10.215	25	.000	-404.6164231	-486.194777	-323.038069

Figure 51: T-test for Blender RF Strength (µW/m²)

Graphical Analysis:

This is a graphical analysis of sample data for our research project. We use 2 graph types for the data: Bar Chart and Column Chart.

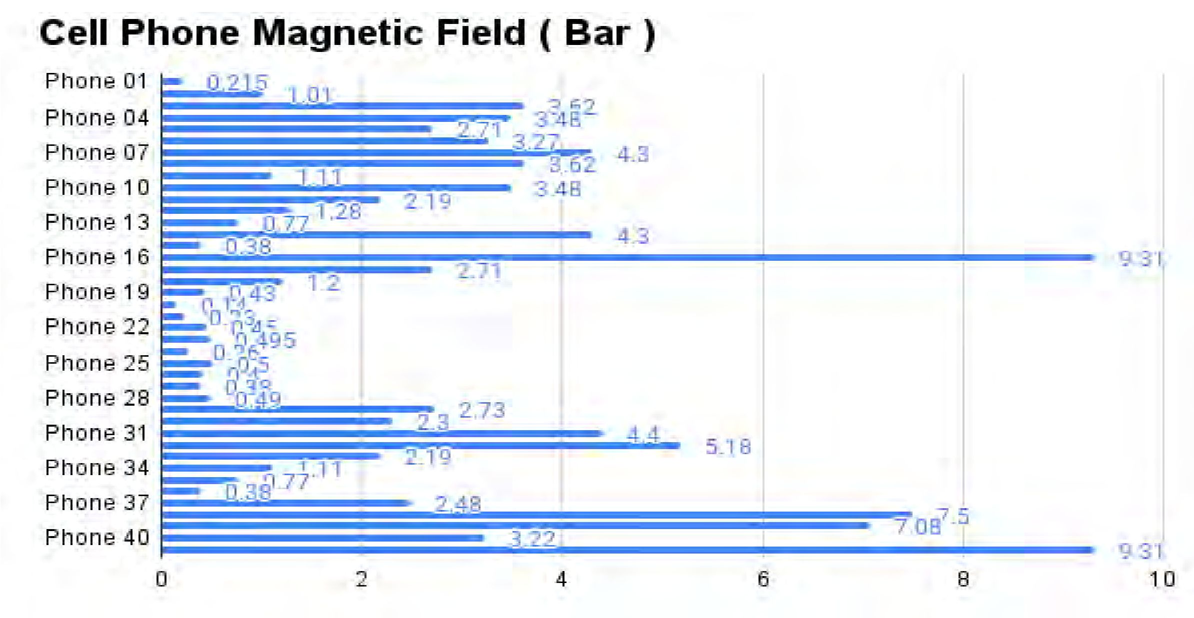

Figure 52: Cell Phone Magnetic Field (mG) Bar Chart

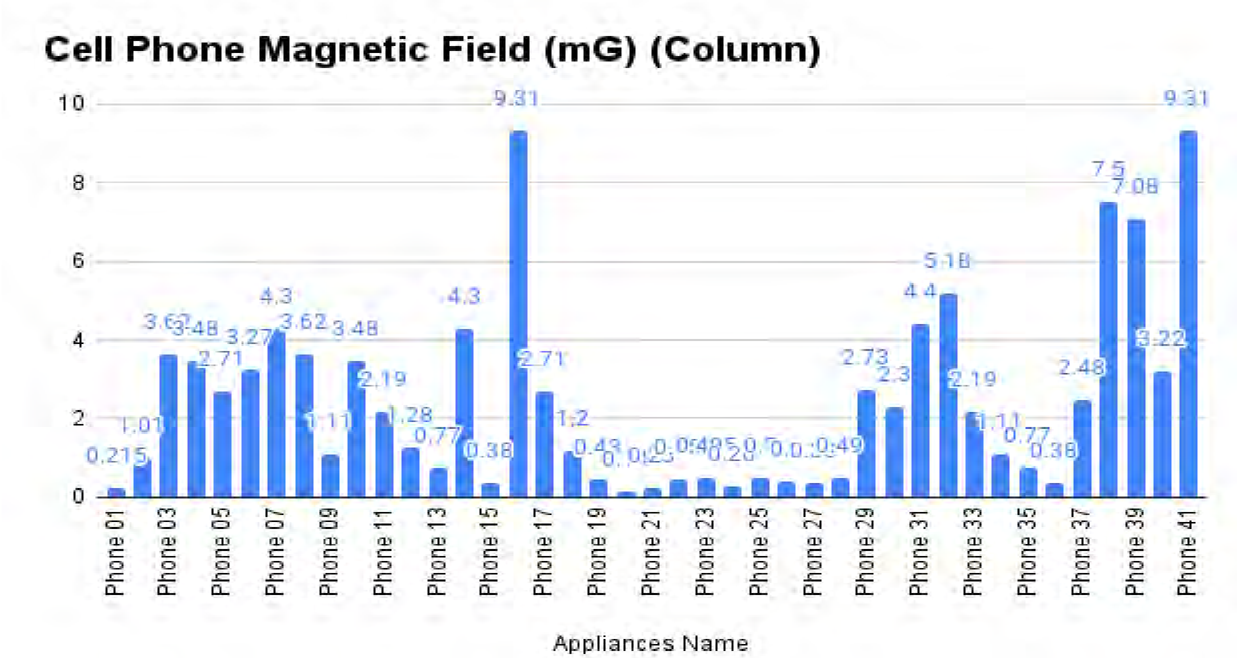

Figure 53: Cell Phone Magnetic Field (mG) Column Chart

A bar chart and a column chart are used to assess the magnetic field intensity data from cell phones. Forty-one cell phones provided the data. Only two of these phones were discovered to be near the threshold, which is 9.31 mG. Other phones' magnetic field emissions are below the limit and in acceptable measures.

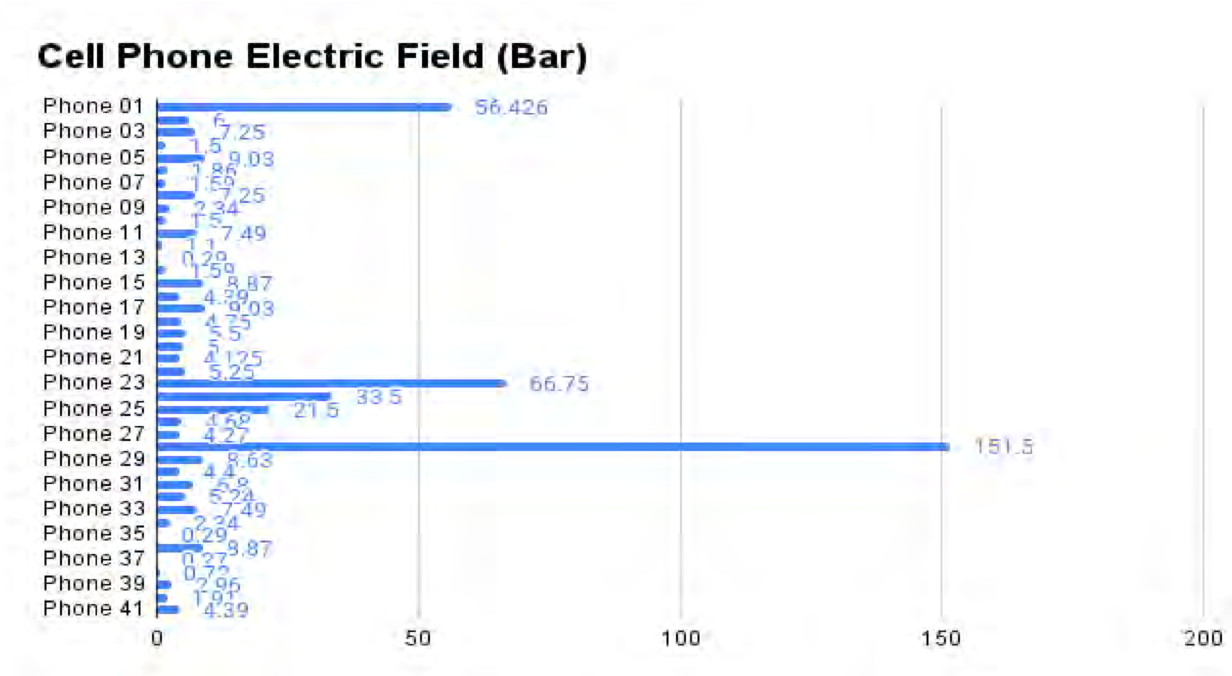

Figure 54: Cell Phone Electric Field (V/m) Bar Chart

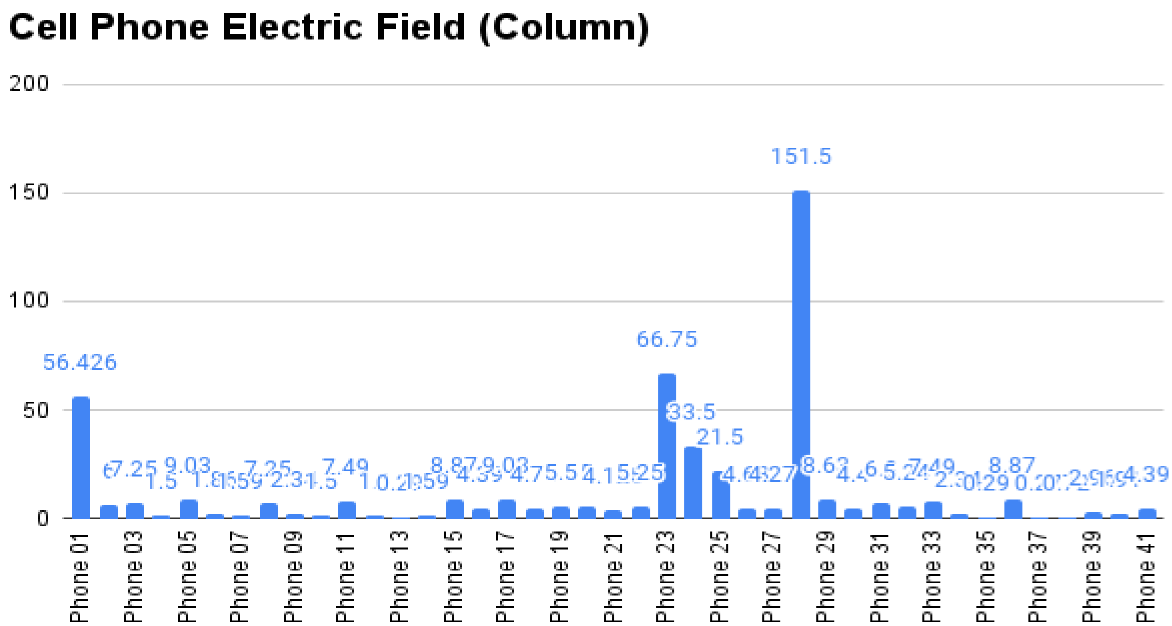

Figure 55: Cell Phone Electric Field (V/m) Column Chart

Data on electric field emissions was gathered from 41 mobile phones. The data was shown by a Bar chart and Column chart. We may conclude that phones number 1, 23, and 28 have the highest emissions out of all of them. The most electric field emission came from phone number 28. Additionally, very little electric field radiation was released by other phones.

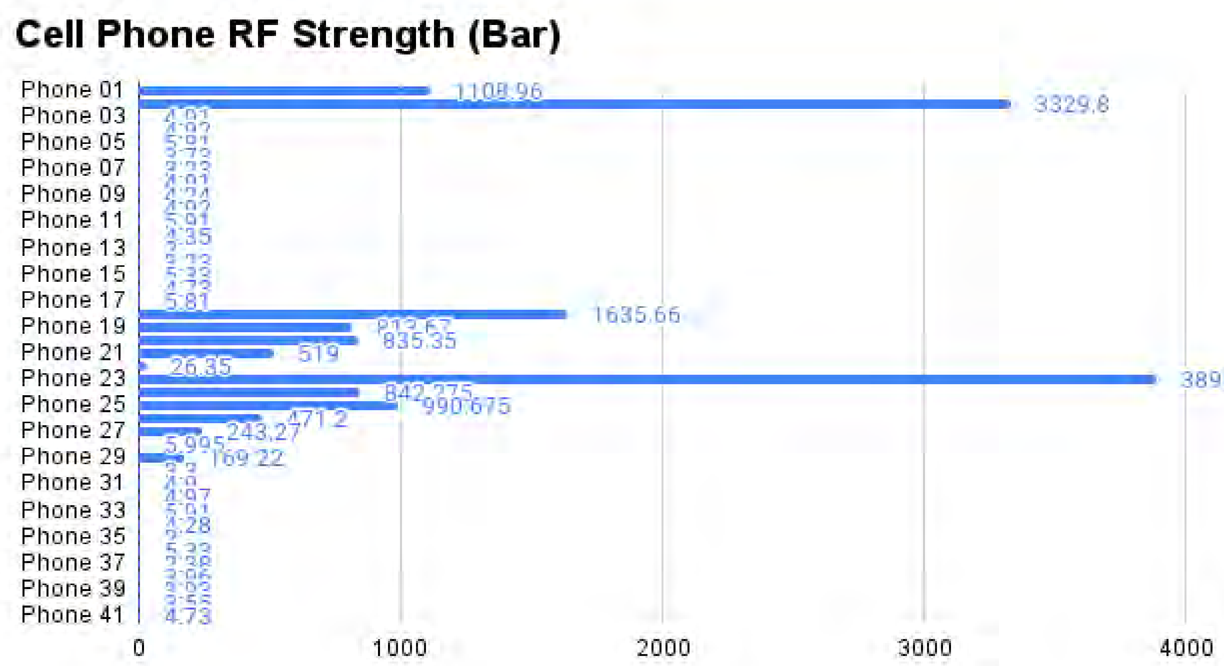

Figure 56: Cell Phone RF Strength (µW/m²) Bar chart

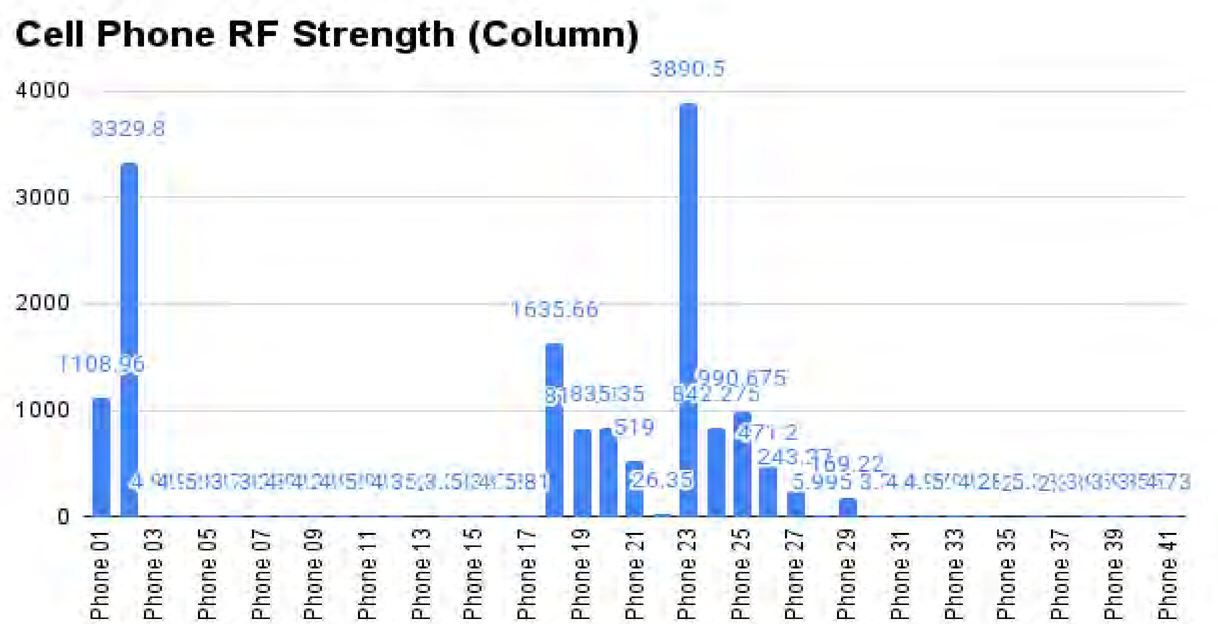

Figure 57: Cell Phone RF Strength (µW/m²) Column Chart

Data on RF strength emissions was gathered from 41 mobile phones. A column chart and a bar are used to display the data. As we can see, two phones generate RF signals with more intensity than the others. Most of the emissions fall below the threshold. However, the majority of phones were found to be 3 to less than 2000 µW/m². The maximum emission detected here is 3890.5 µW/m².

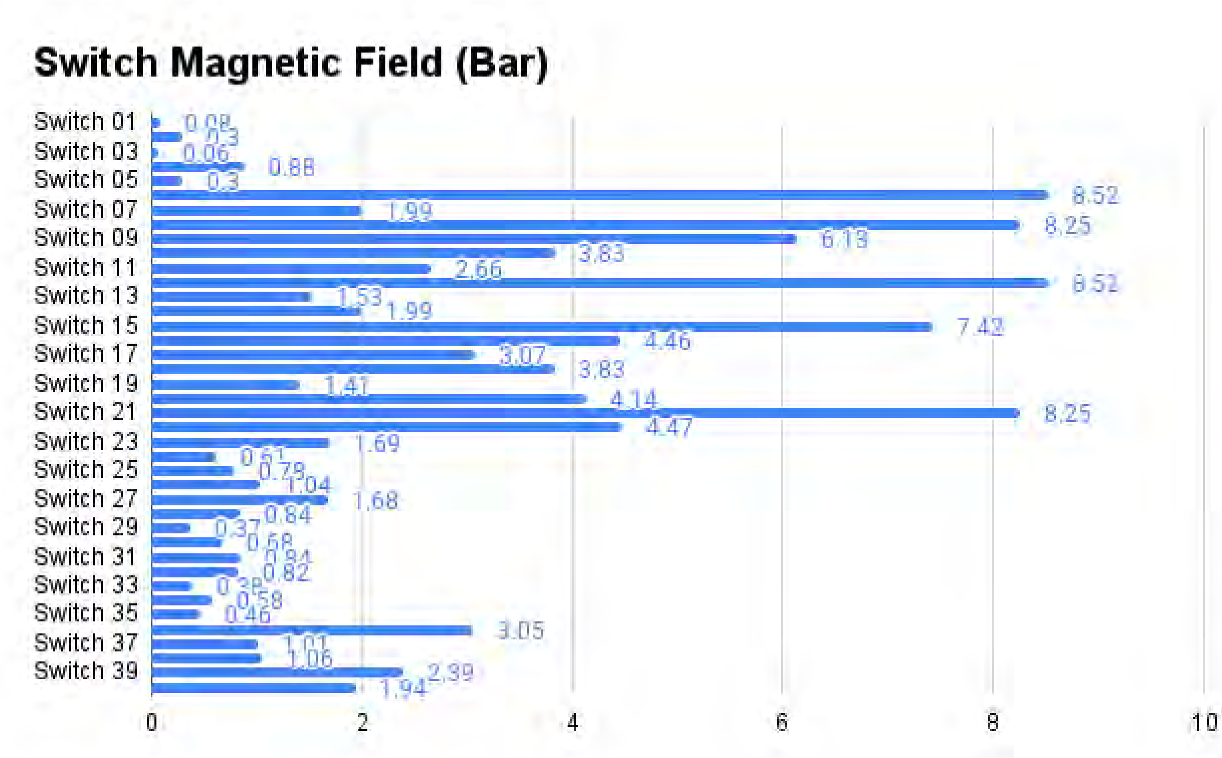

Figure 58: Switch Magnetic Field (mG) Bar Chart

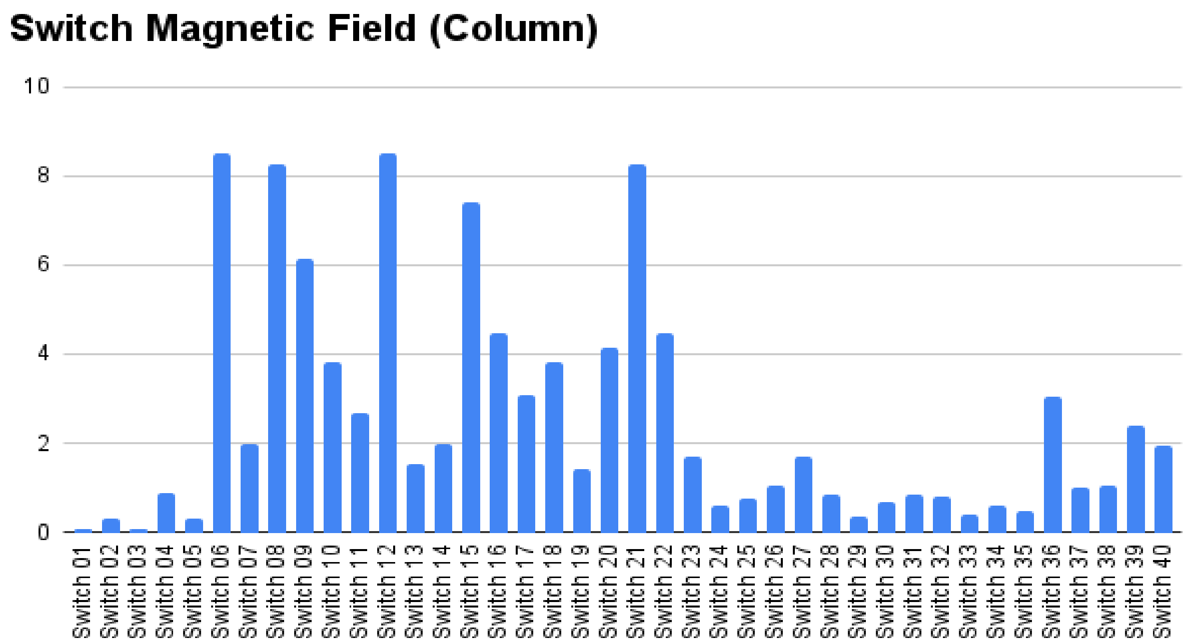

Figure 59: Switch Electric Field Bar Chart

Magnetic field emissions were gathered from 40 electric switchboards. Bar charts and column charts were used to display the data. The majority of the emissions were detected at 1 to 5 milli Gauss (mG). Additionally, the number of emissions is near 9 mG. The maximum magnetic field emission measured in this graph is 8.52 milli Gauss.

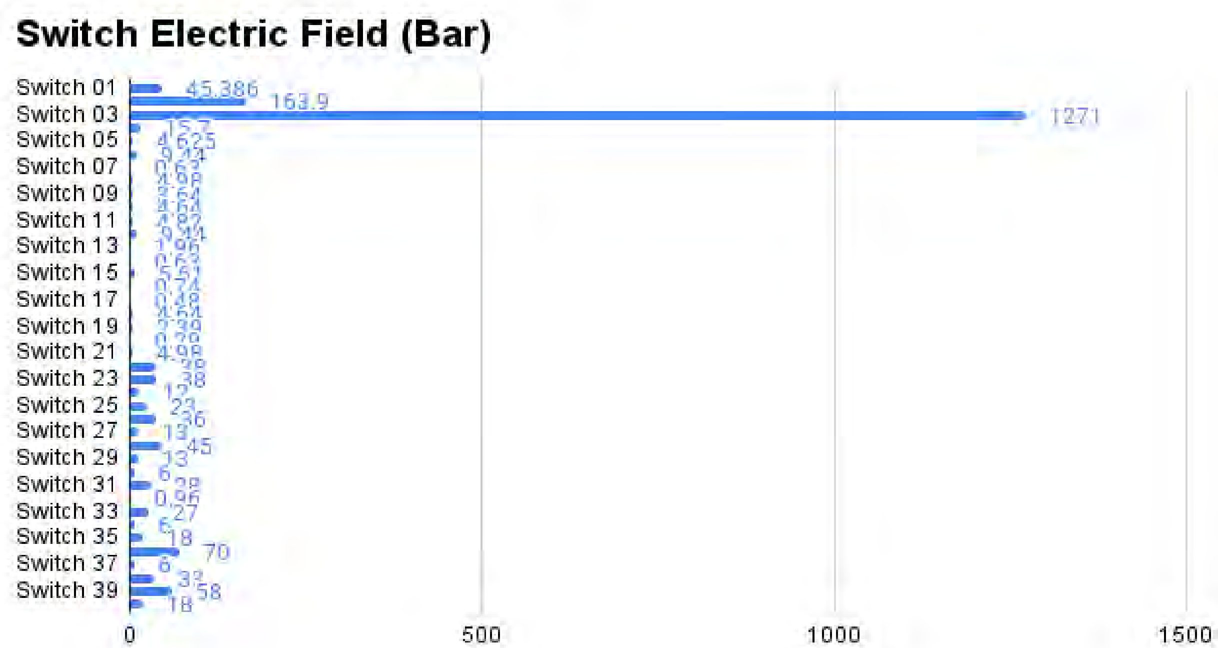

Figure 60: Switch Electric Field (V/m) Bar Chart

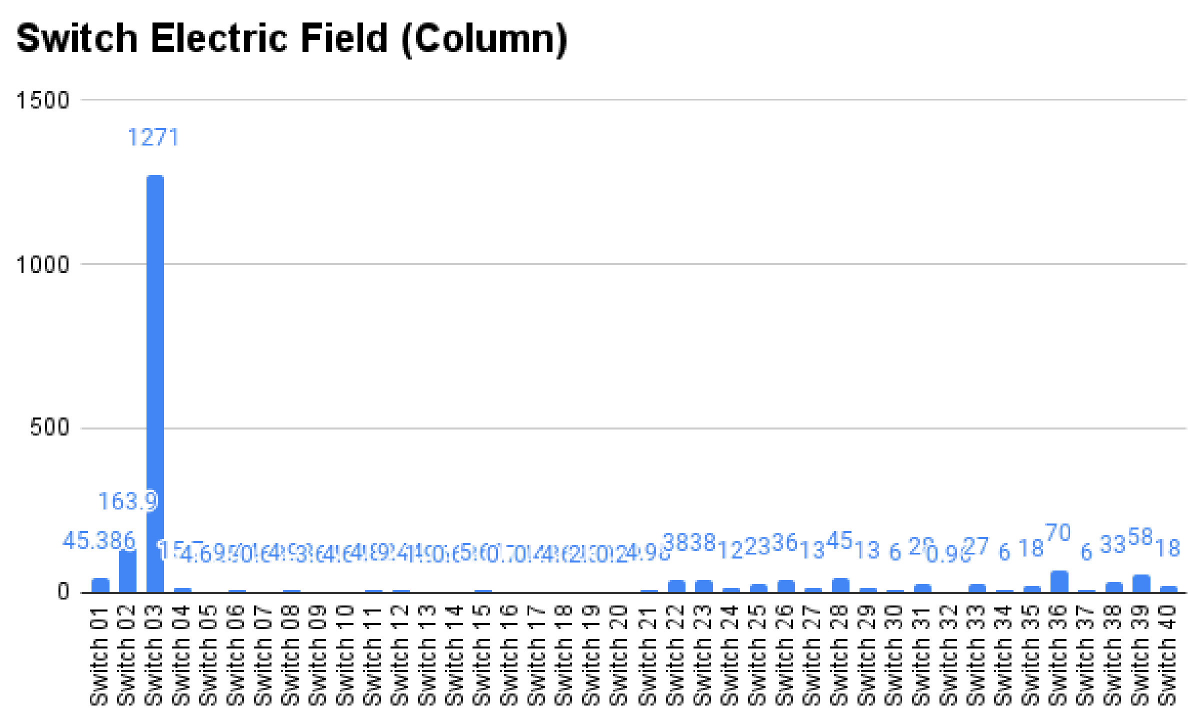

Figure 61: Switch Electric Field (V/m) Column Chart

Electric field emissions are gathered from 40 switchboards. The graph displayed the data as a column chart and a bar. Electric field emissions from switchboards ranged from 0.5 to 165 V/m. There was only one switchboard that was discovered to generate the most electric field radiation, 1271 V/m.

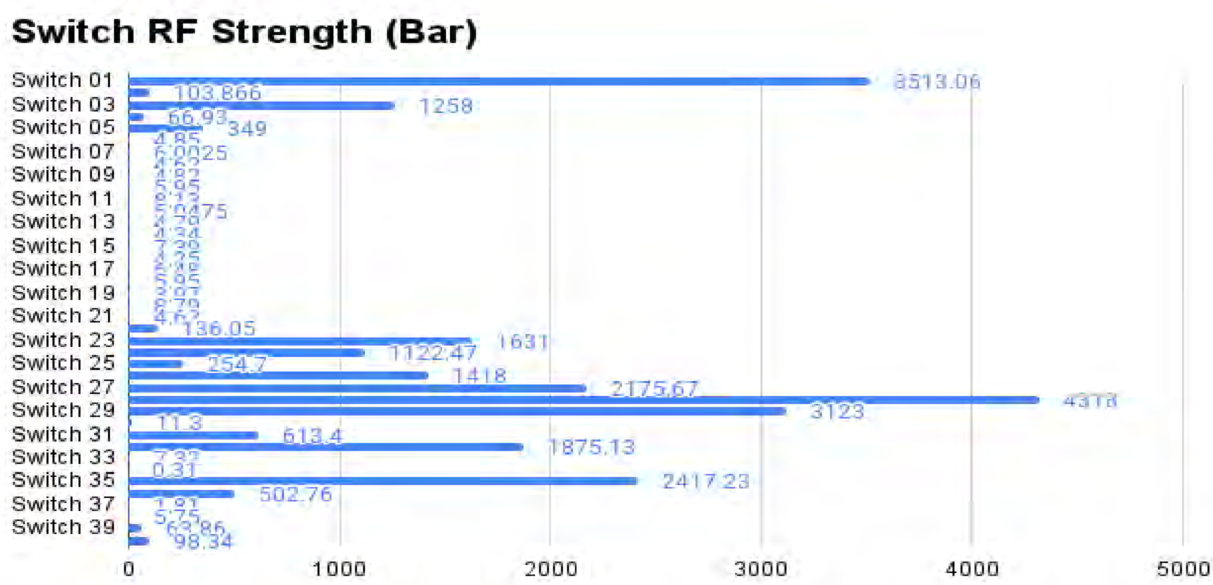

Figure 62: Switch RF Strength (µW/m²) Bar Chart

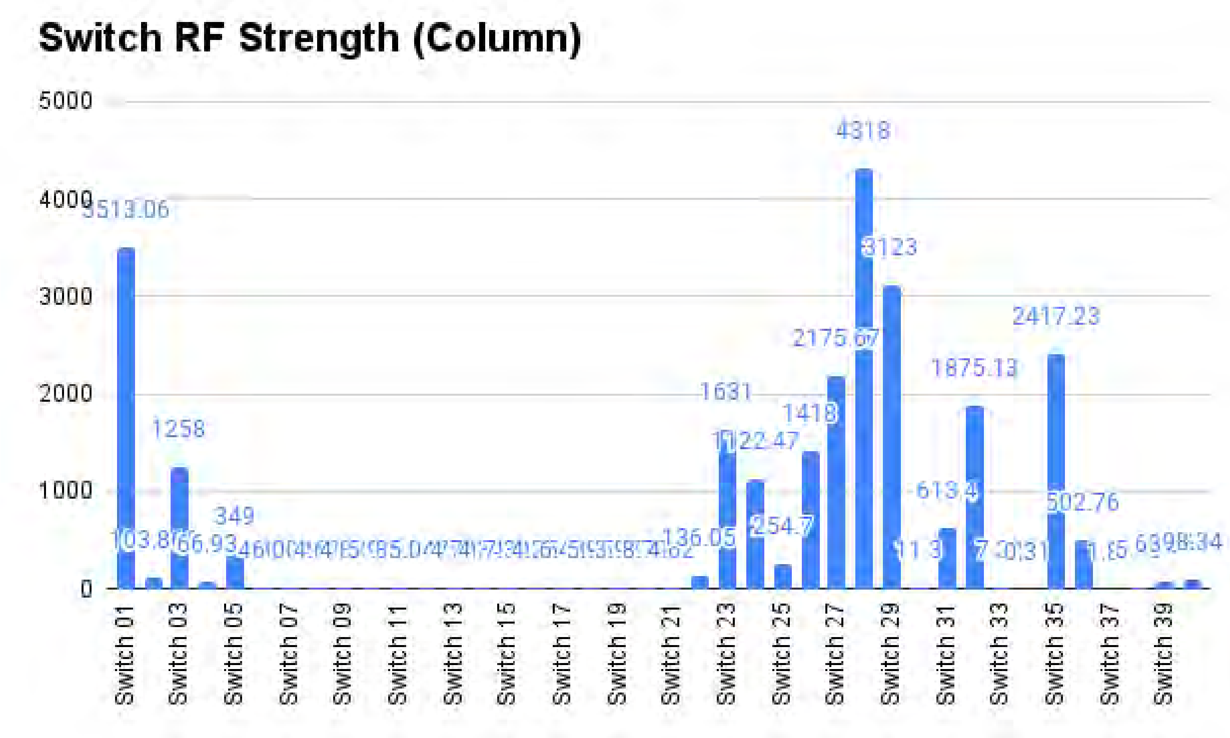

Figure 63: Switch RF Strength (µW/m²) Column Chart

40 switchboards' RF strength emissions were gathered. The graph above displayed the data as a bar and column chart. Several of the data we found were below 3500µW/m². 4318µW/m² is the only data point that was found to be the highest.

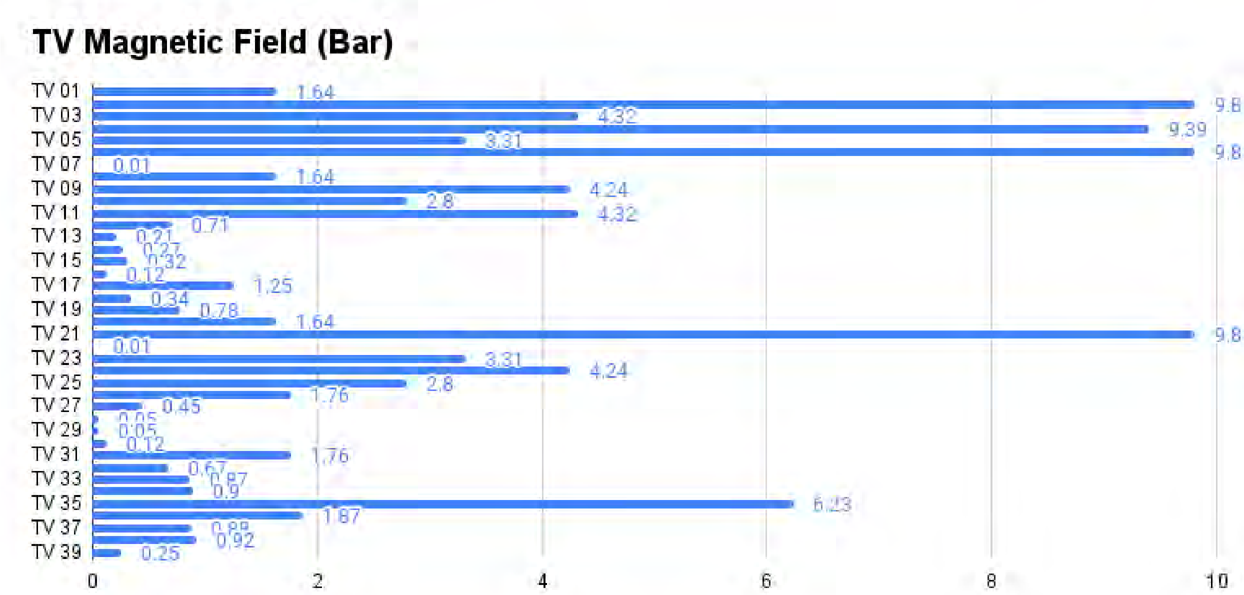

Figure 64: TV Magnetic Field (mG) Bar Chart

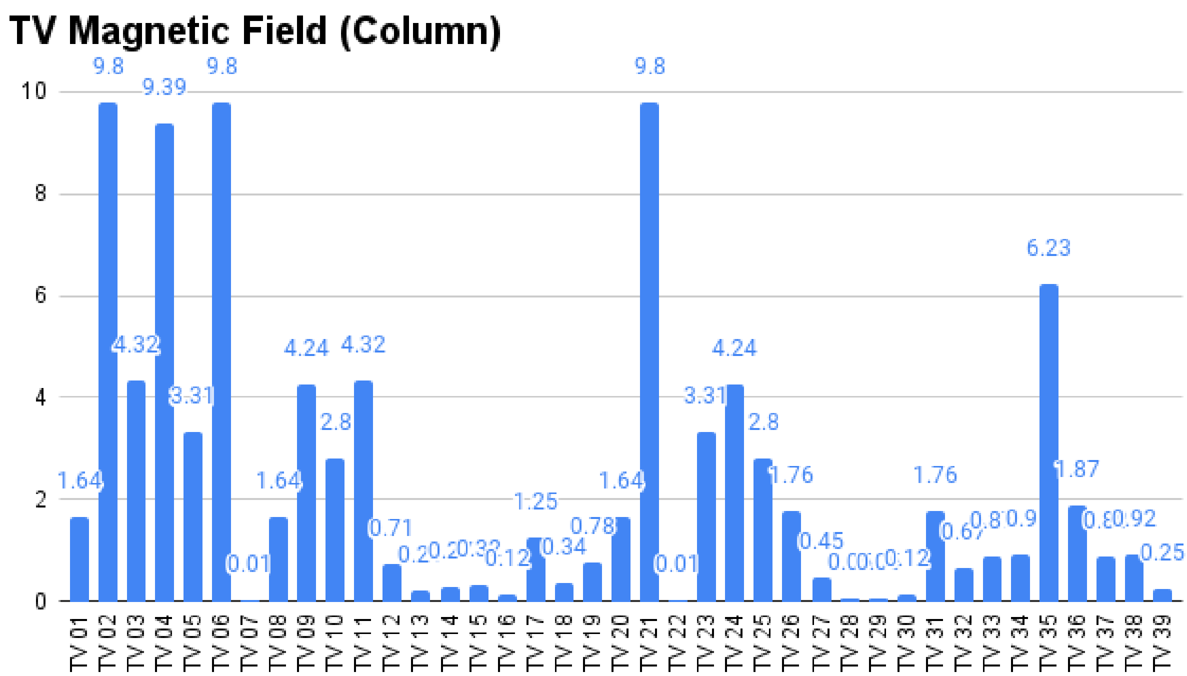

Figure 65: Tv Magnetic Field (mG) Column Chart

We recorded TV magnetic field emission. We gathered this information from 39 televisions. The graph displays the data as a column chart and a bar chart. We discovered that magnetic field emission from more than 35 tvs ranges from 0.01 to 7 milli Gauss (mG). A small number of televisions also released the strongest radiation, which is 9.8 milli Gauss (mG).

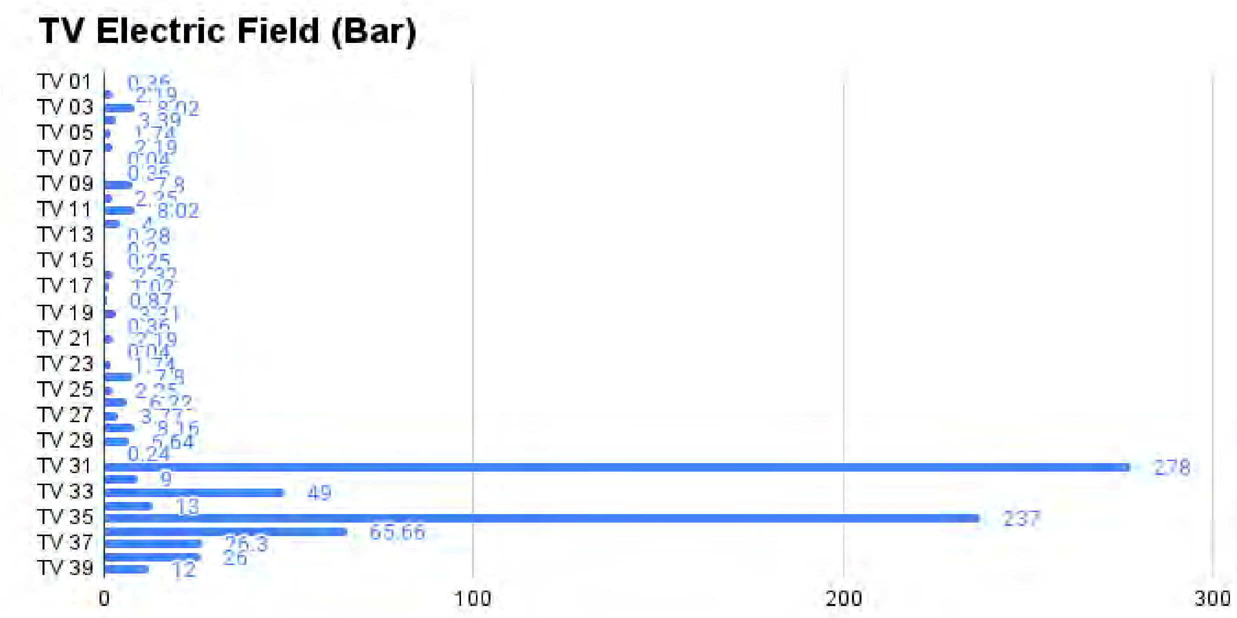

Figure 66: TV Electric Field (V/m) Bar Chart

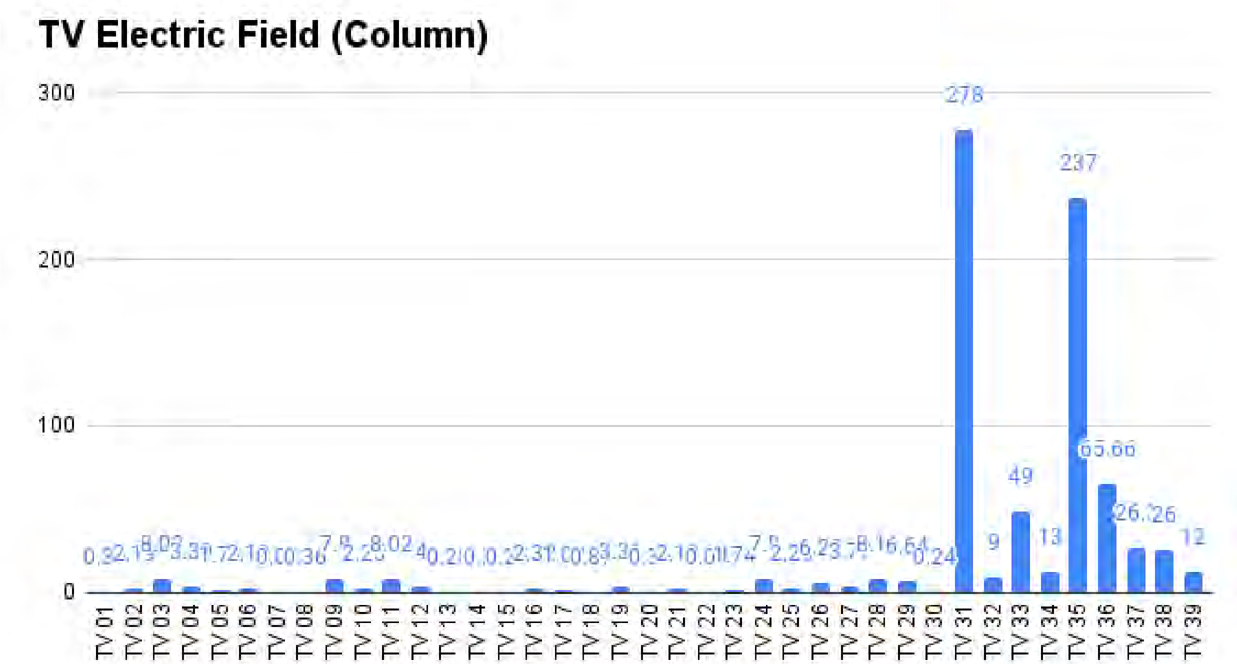

Figure 67: TV Electric Field (V/m) Column Chart

From 39 televisions, we gathered electric field emissions. Both a bar chart and a column chart are used to display the data. The electric field output from 37 of the 39 TVs was less than 70 V/m. Emissions of 278 and 237 V/m were the highest.

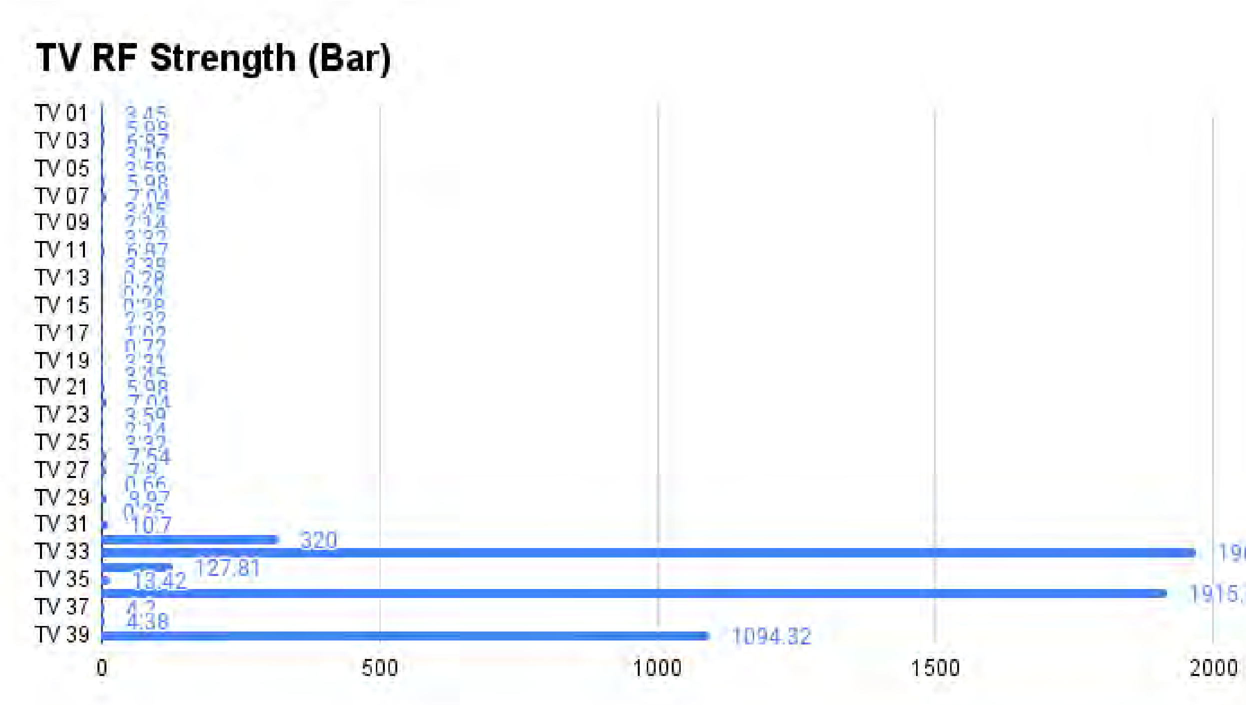

Figure 68: TV RF Strength (µW/m²) Bar Chart

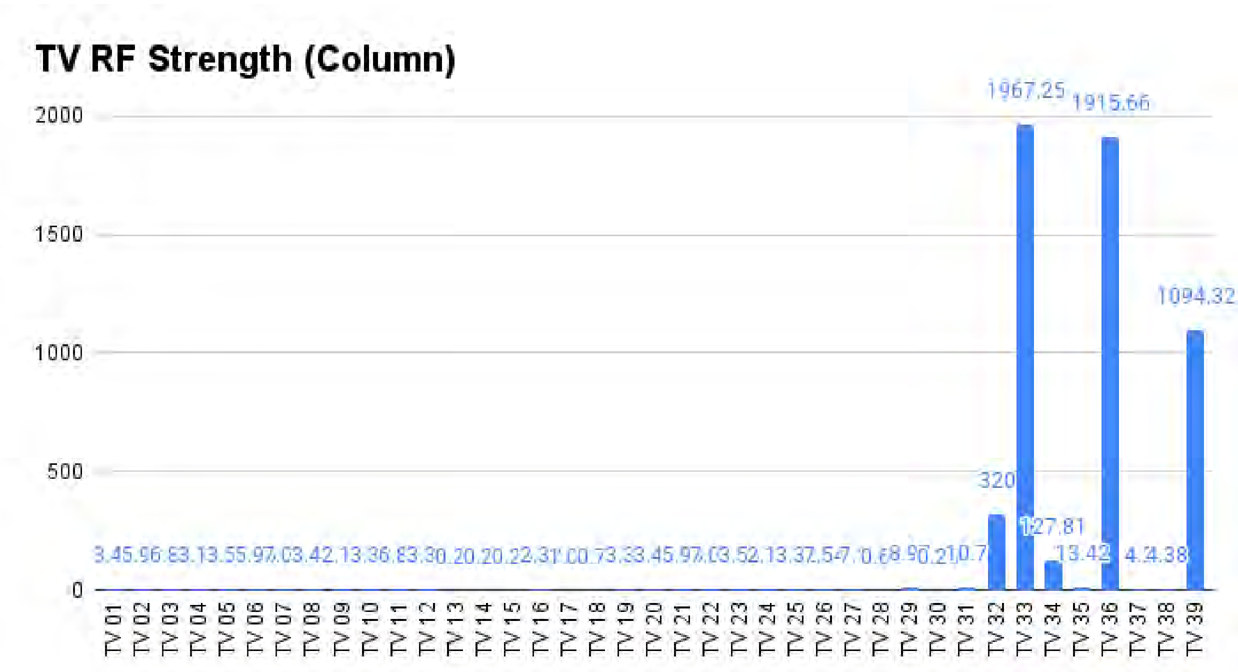

Figure 69: TV RF Strength (µW/m²) Column Chart

From 39 televisions, we gathered RF strength emissions. The graph displays the data as a column chart and a bar chart. The RF strength output from the 36 TVs was less than 350µW/m². The RF intensity of the other three TVs is between 1000 and 2000 µW/m². The highest RF strength measured here is 1967.25µW/m².

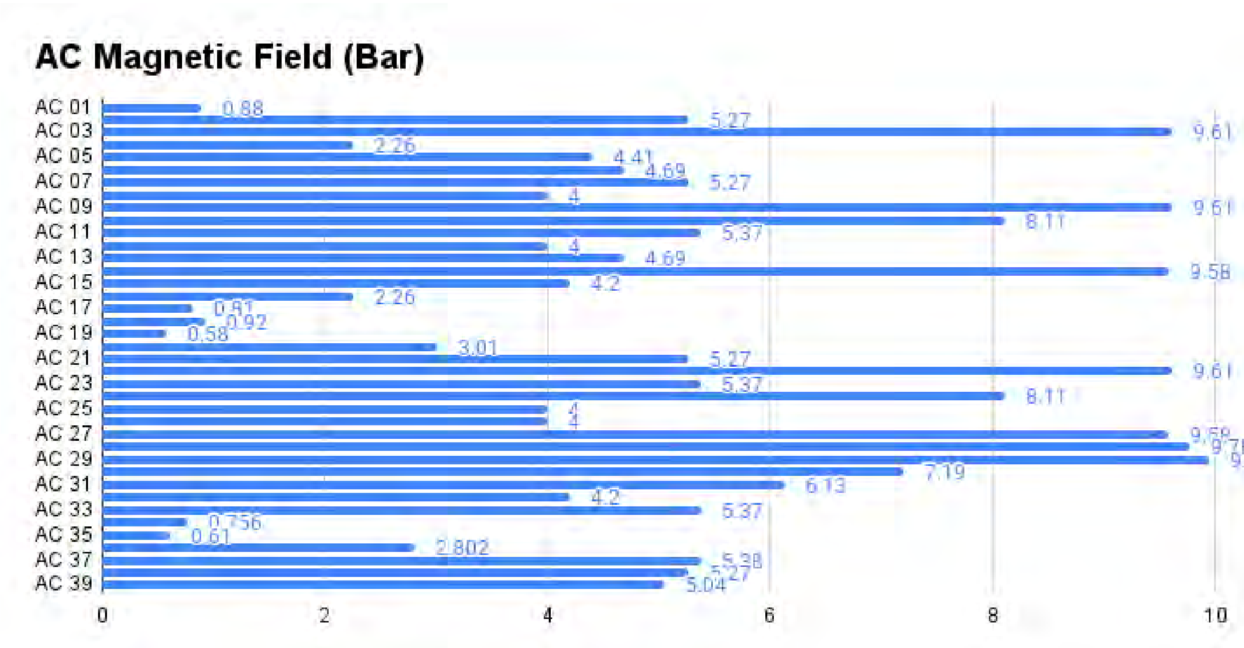

Figure 70: AC Magnetic Field (mG) Bar Chart

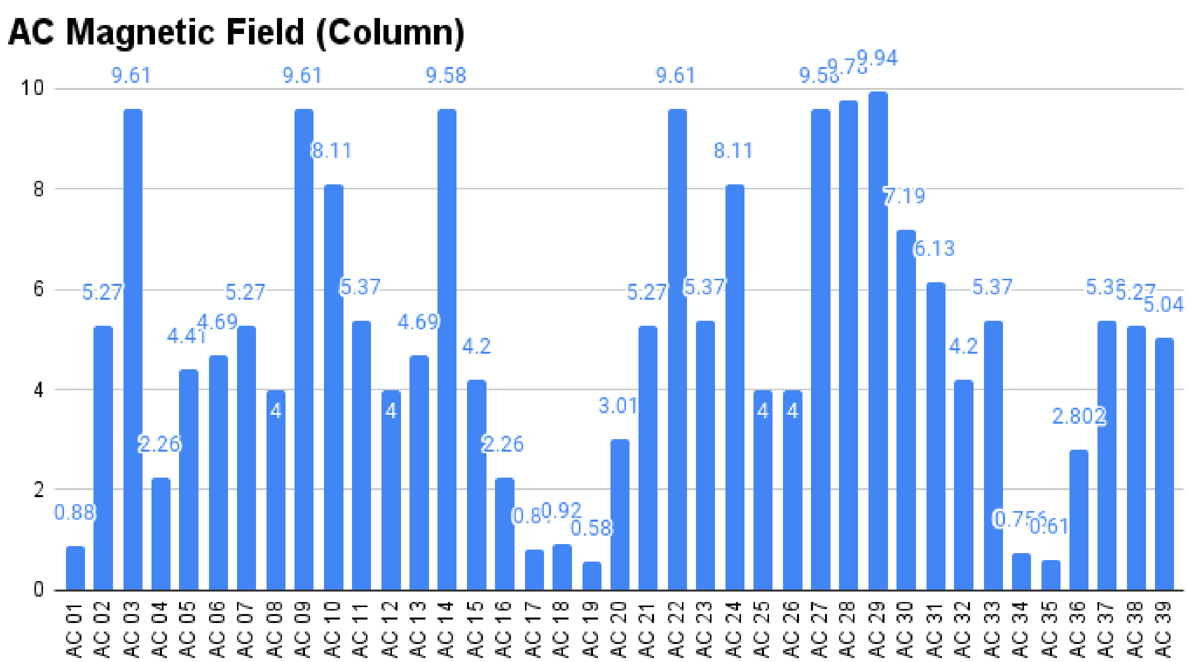

Figure 71: AC Magnetic Field (mG) Column Chart

We gathered magnetic field emissions from 39 ACs. The graph displays the data as a column chart and a bar chart. The emission fluctuation is visible in every AC. The maximum magnetic emission measured here was 9.94 milli Gauss (mG).

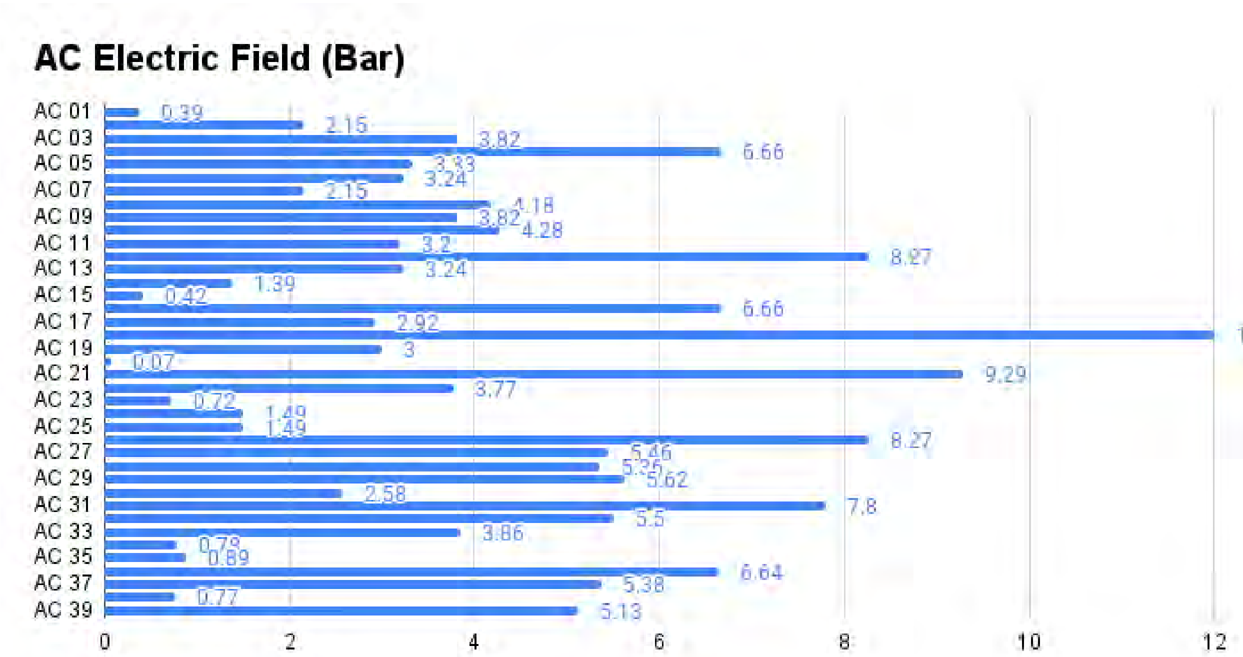

Figure 72: AC Electric Field (V/m) Bar Chart

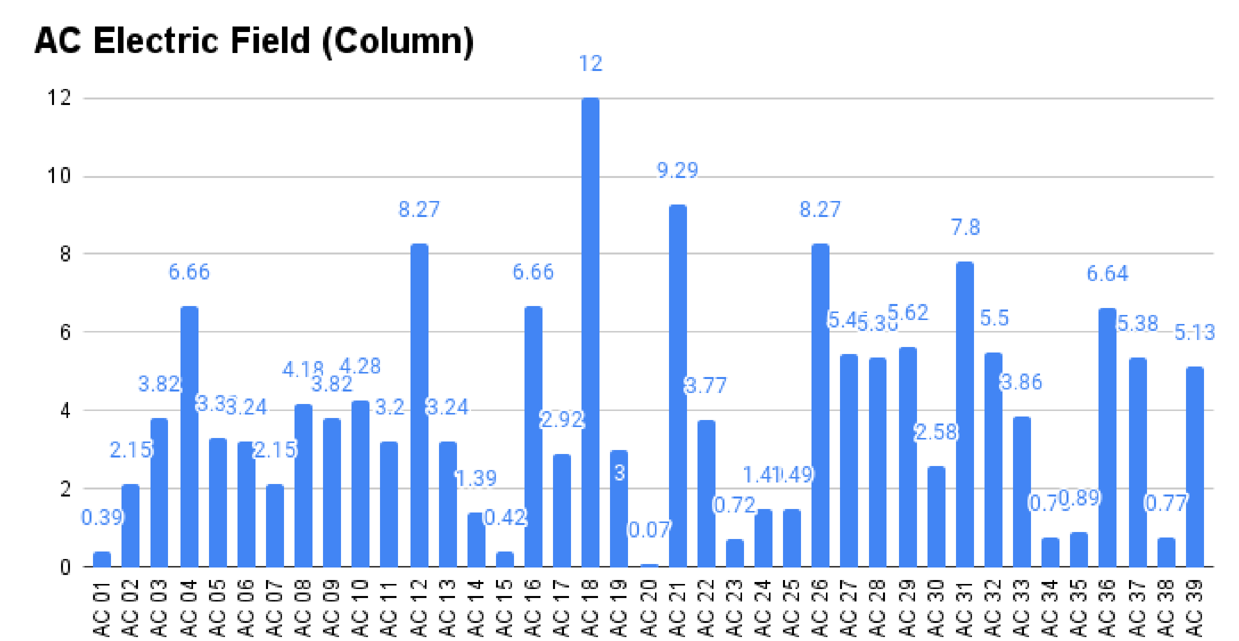

Figure 73: AC Electric Field (V/m) Column Chart

We gathered 39 ACs' electric field emissions. the information is displayed as a column chart and bar chart in the graph. The variation of electric field emissions is also seen here. This area's lowest electric field emissions are 0.07 V/m, whereas many emissions are nearly 10 V/m. The maximum electric emission measured was 12 V/m.

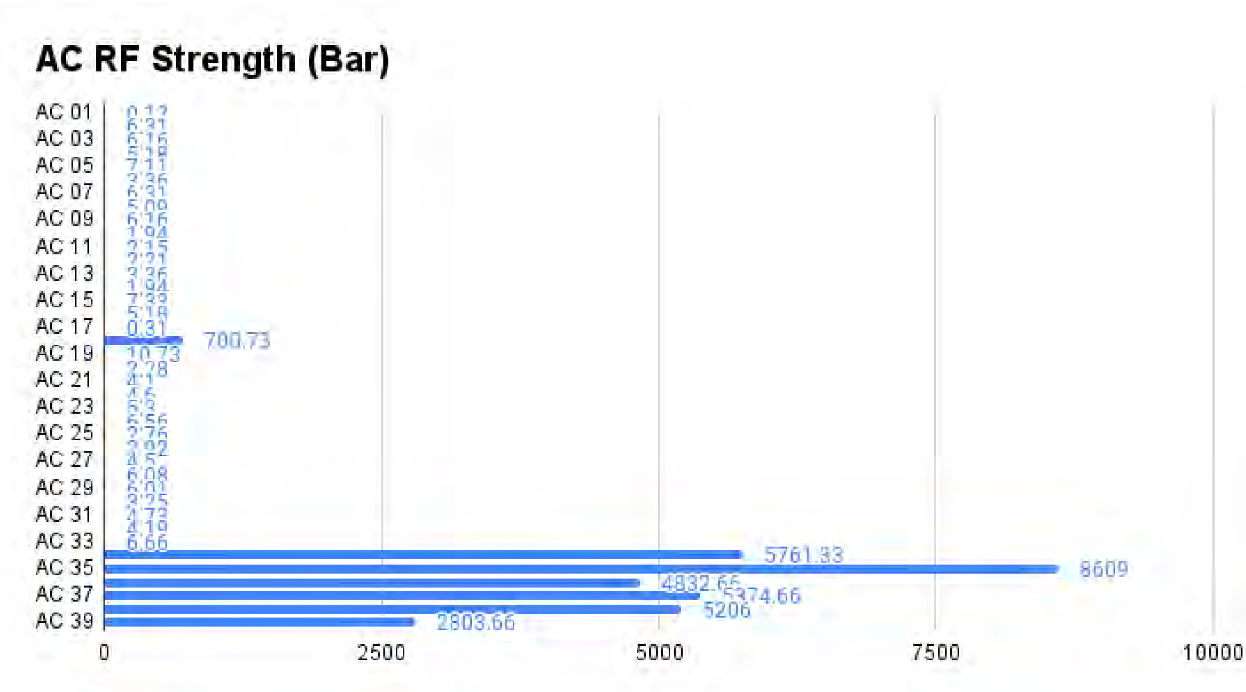

Figure 74: AC RF Strength (µW/m²) Bar Chart

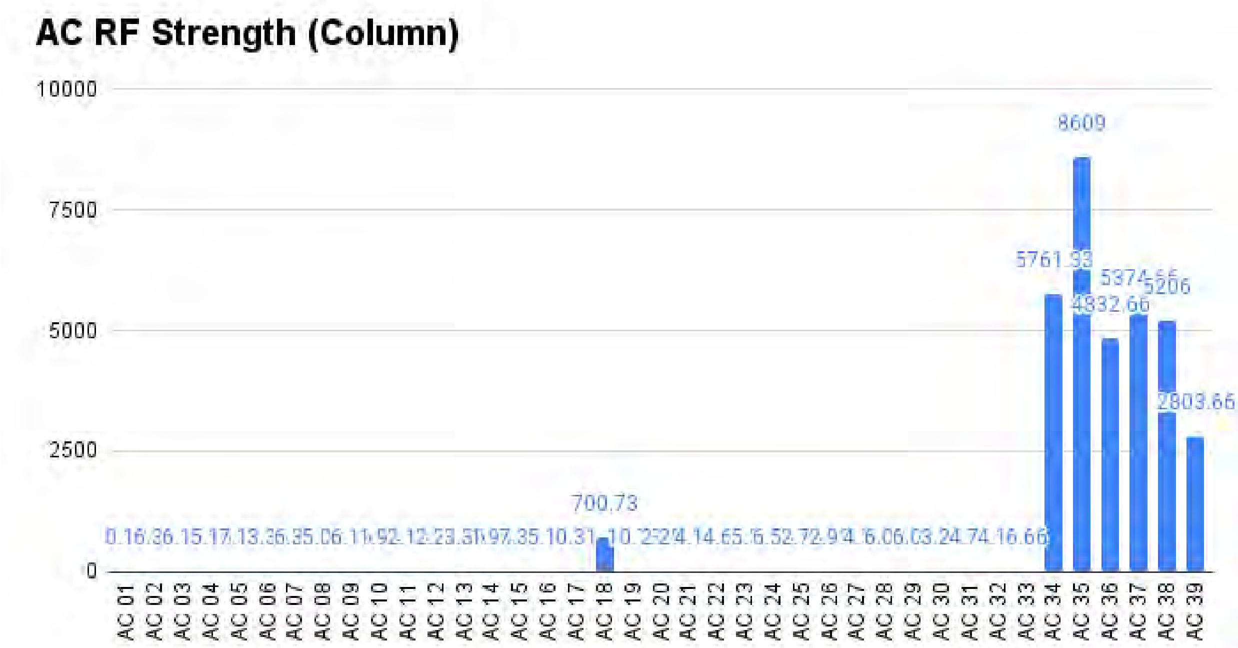

Figure 75: AC RF Strength (µW/m²) Column Chart

We gathered 39 ACs' RF strengths. The graph displayed the data as both a column chart and a bar chart. 0.16µW/m² is the lowest Rf strength. The emission of a few RF strengths ranged from 2800 to 5800µW/m². 8609µW/m² was the highest RF strength emission detected.

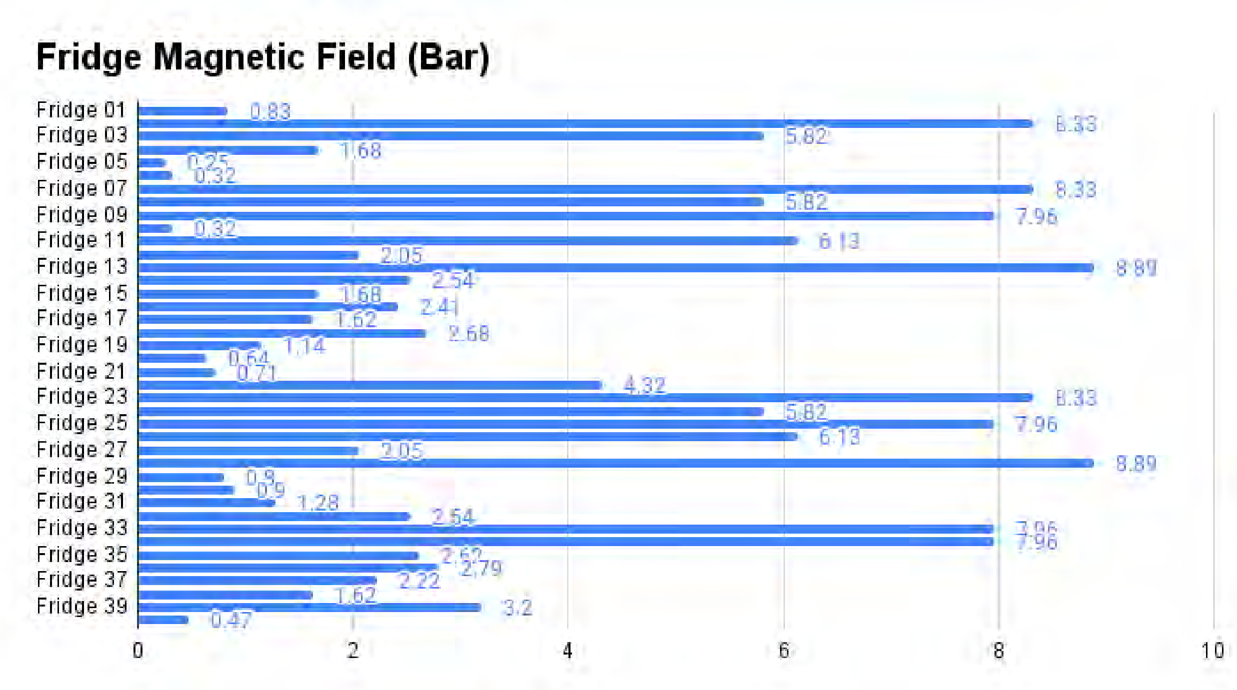

Figure 76: Fridge Magnetic Field (mG) Bar Chart

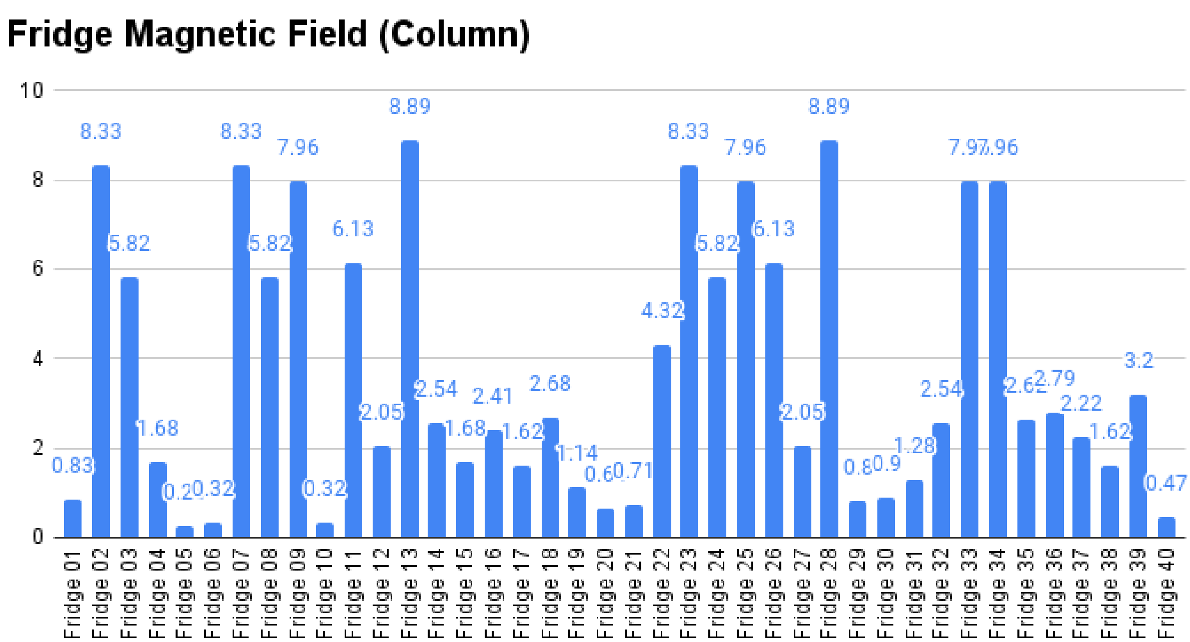

Figure 77: Fridge Magnetic Field (mG) Column Chart

Magnetic field emissions were gathered from 40 refrigerators. The graph displayed the data in both bar and column charts. The graph shows the fluctuation of the magnetic field emission. The lowest magnetic field emission, measured at 0.2V/m, was recorded from Fridge No. 5. Additionally, the magnetic emissions from a few refrigerators were near 9V/M. The maximum magnetic field emission measured was 8.89V/m.

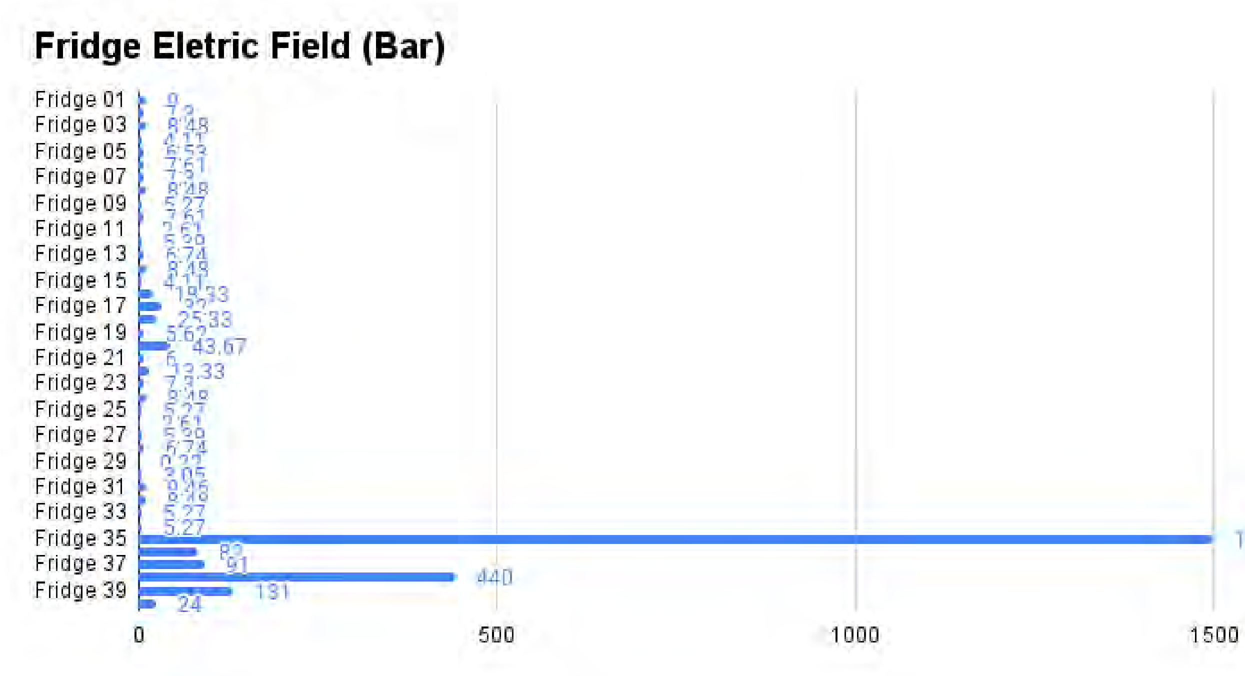

Figure 78: Fridge Electric Field (V/m) Bar Chart

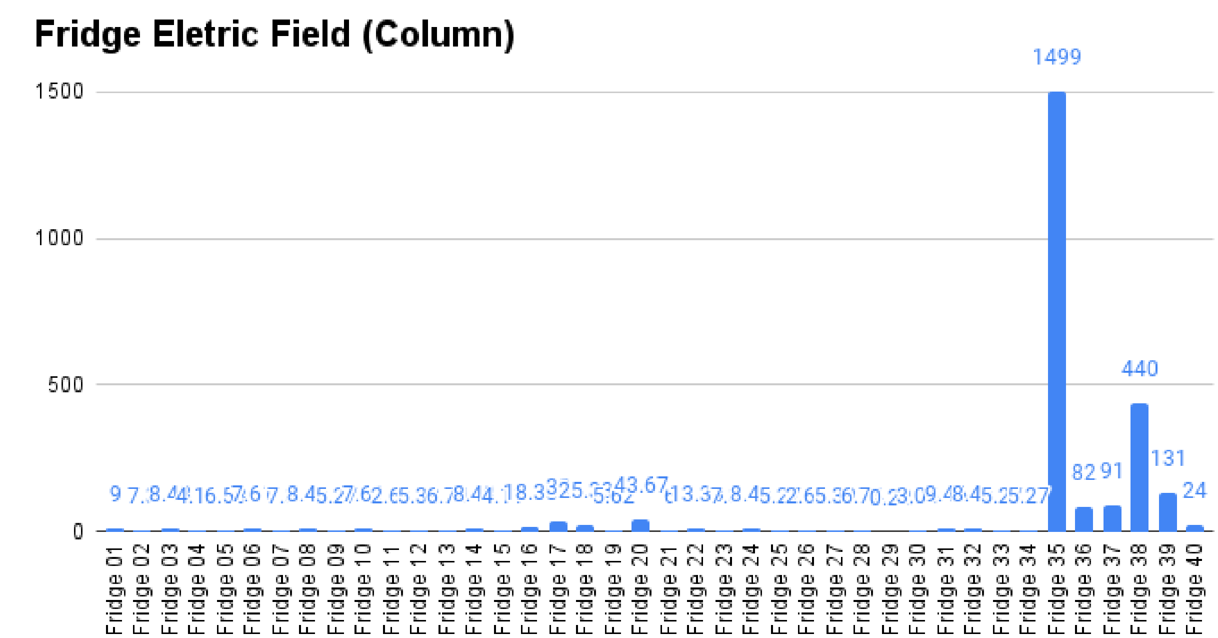

Figure 79 : Fridge Electric Field (V/m) Column Chart

We gathered information from 40 refrigerators. The graph displays the data as a bar and a column. Nearly the majority of the refrigerators had electric field emissions between 0.2 and 10 V/m. Additionally, certain electric field electromagnetic fields exceeded 100 to 500 V/m. The observed peak electric field emission was 1499V/m.

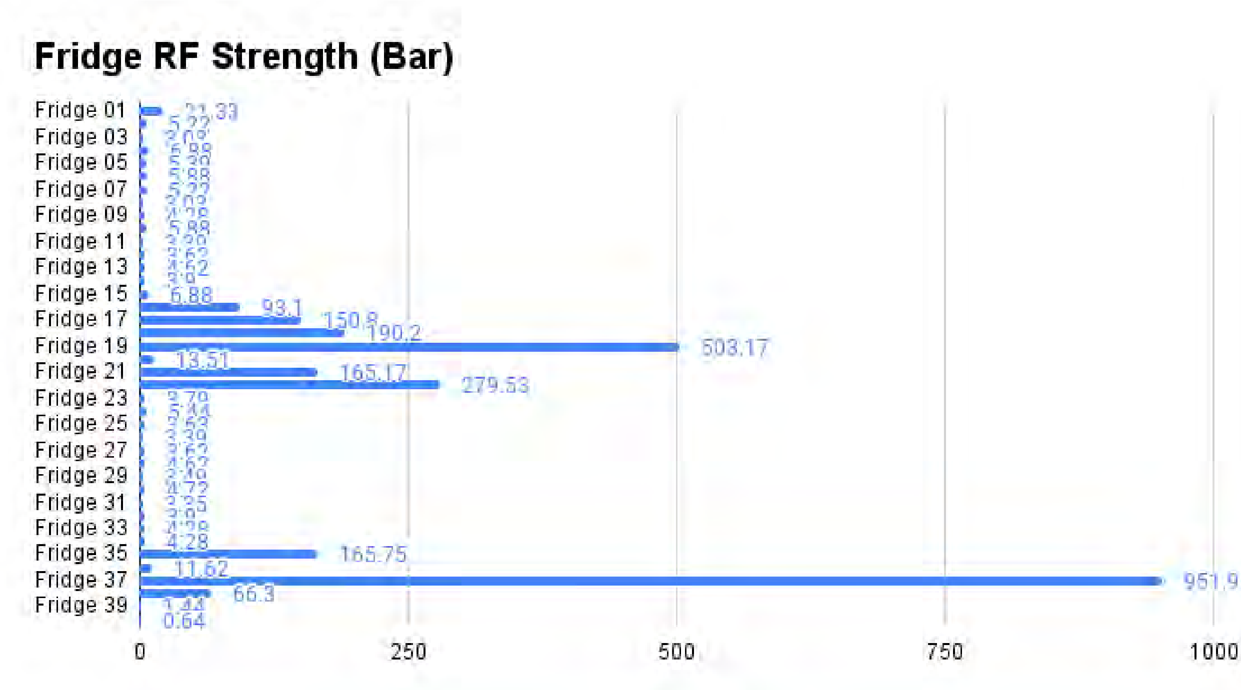

Figure 80: Fridge RF Strength (µW/m²) Bar Chart

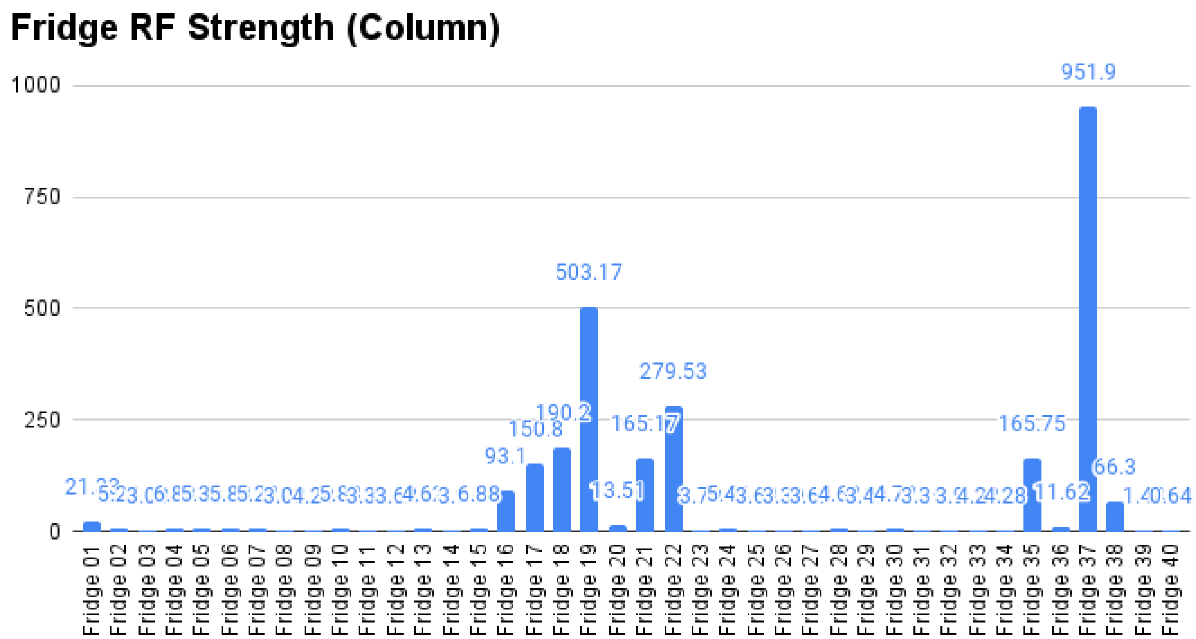

Figure 81: Fridge RF Strength (µW/m²) Column Chart

From 40 refrigerators, we gathered the RF strength. The graph displayed the data in both bar and column charts. The majority of the RF strength emissions, as seen in the graph, were between 0.6 and 500µW/m². The maximum Rf strength emission of 951.9µW/m² was discovered.

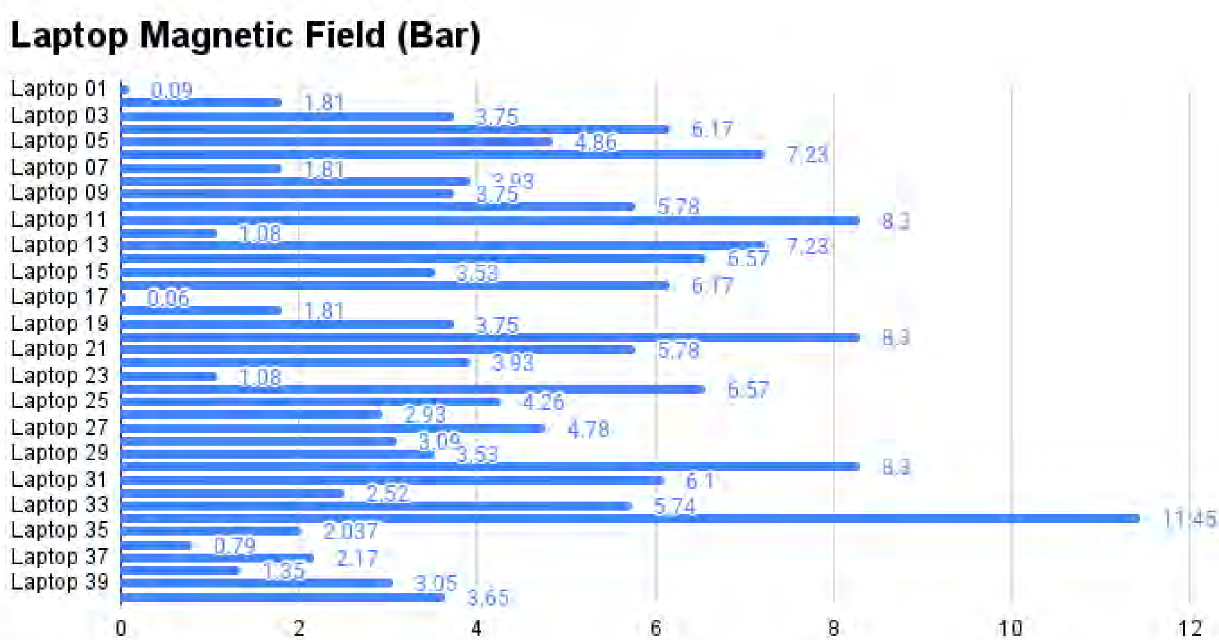

Figure 82: Laptop Magnetic Field (mG) Bar Chart

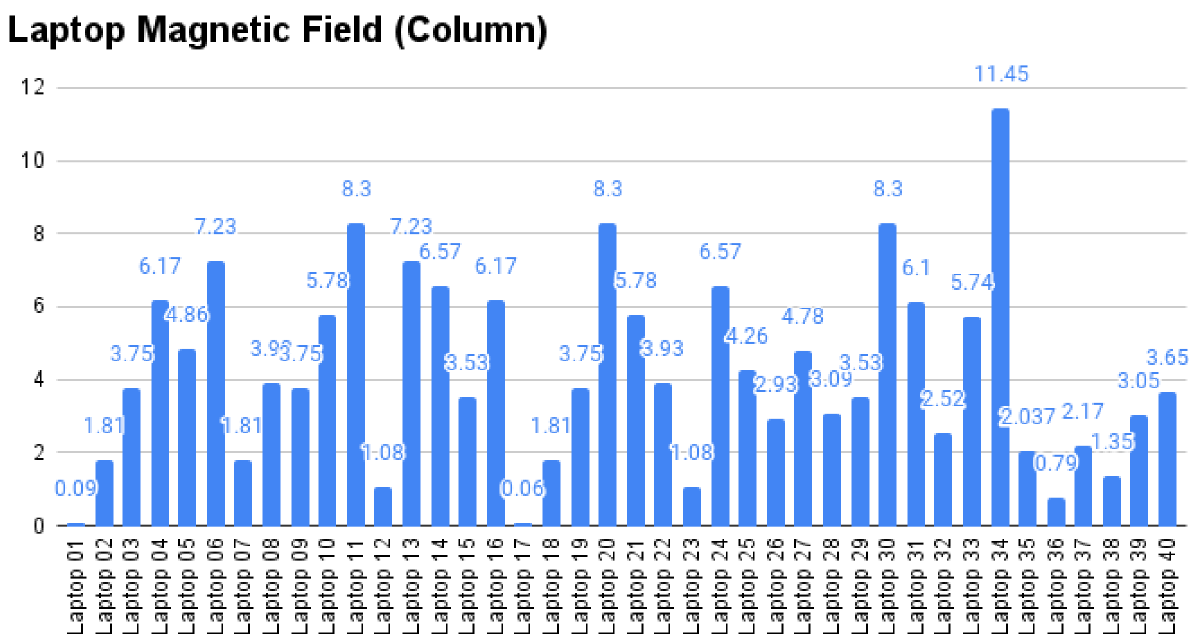

Figure 83: Laptop Electric Field (V/m) Column Chart

We gathered 40 laptops' magnetic field emissions. The graph displayed the data as both a column chart and a bar chart. Here, the variations in magnetic field emissions are visible. The lowest magnetic field emissions that we could find were 0.06 milli Gauss (mG). The majority of the emissions were also between 0.06 and 8.3 mG. The maximum observed magnetic field intensity was 11.45 milli Gauss (mG).

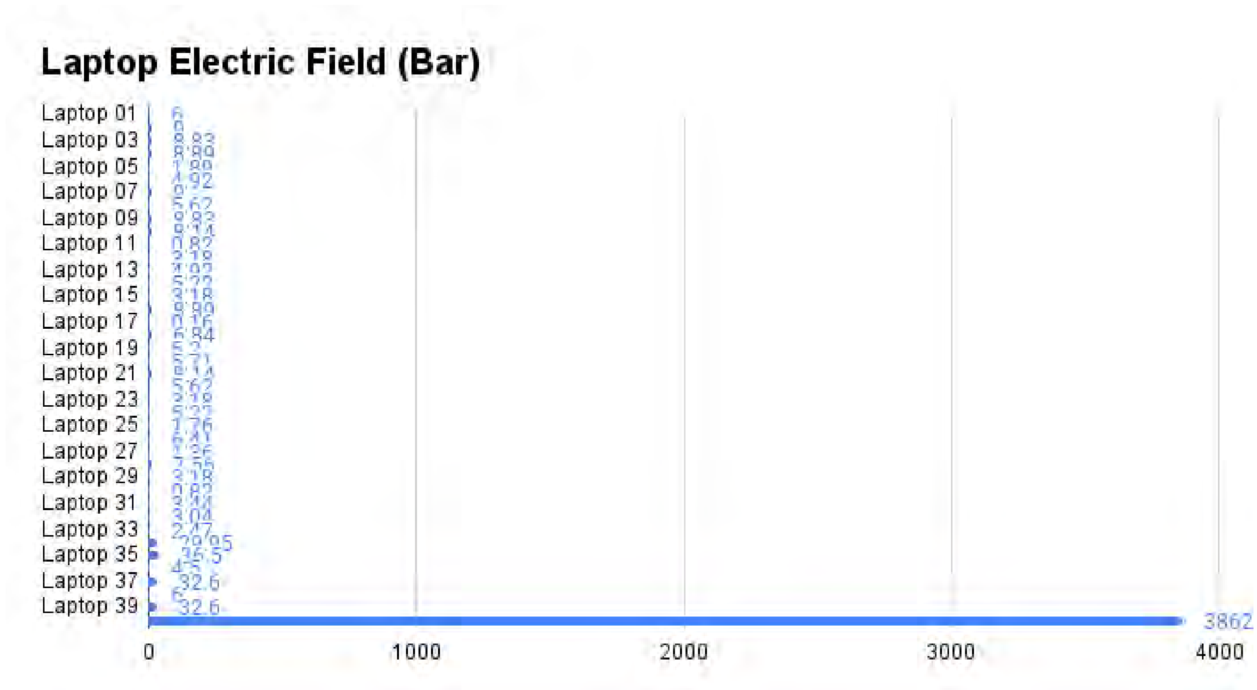

Figure 84: Light Electric Field (V/m) Bar Chart

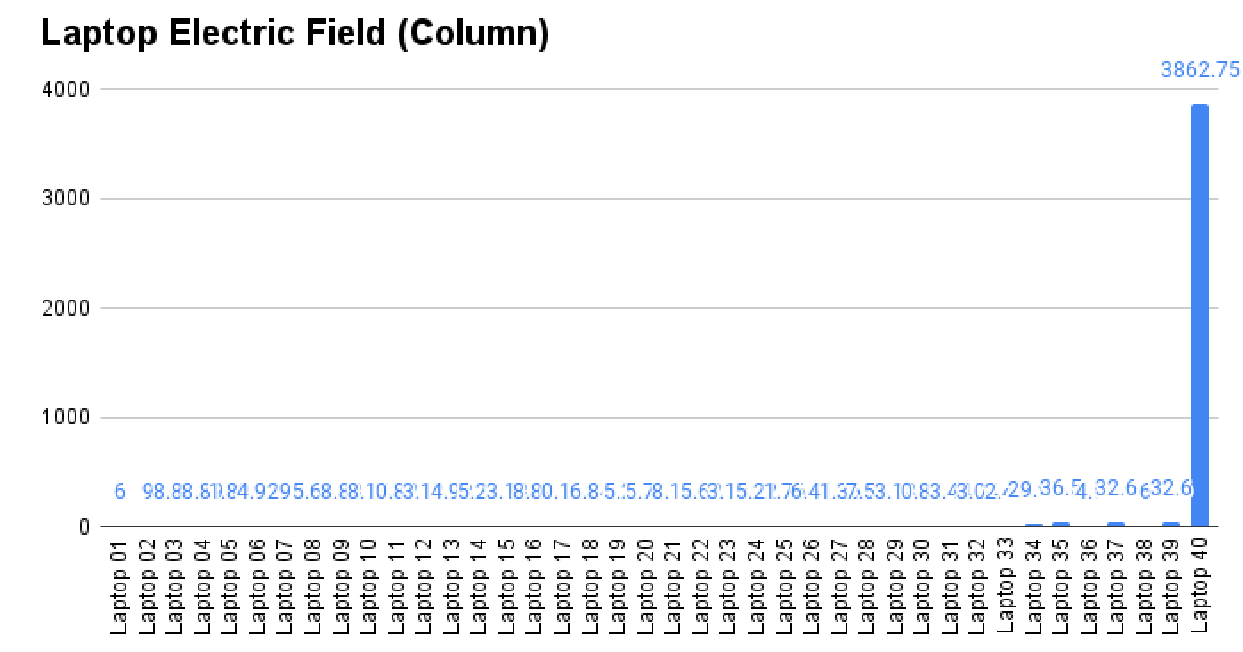

Figure 85: Laptop Electric Field (V/m) Column Chart

From 40 laptops, we gathered electric field emissions. Both a bar chart and a column chart displayed the data. Nearly every electric field emission, as we can see, ranged from 0.8 V/m to 35 V/m. The maximum recorded electric field outputs were 3862.75 V/m.

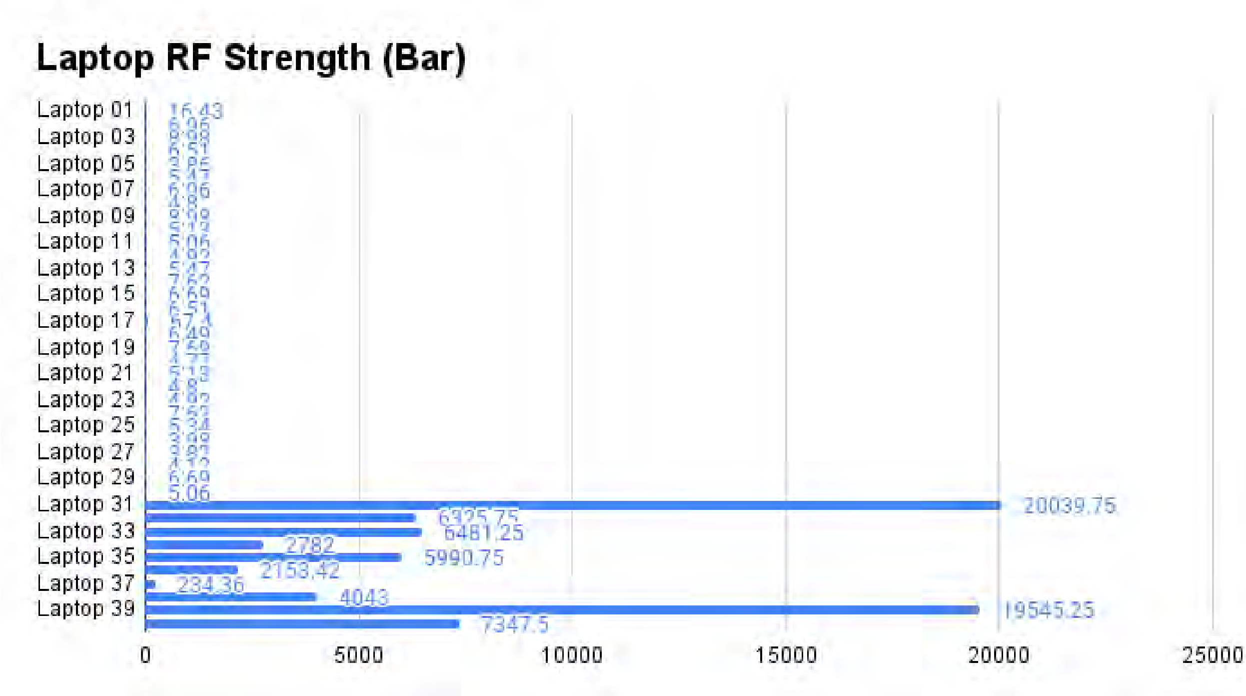

Figure 86: Laptop RF Strength (µW/m²) Bar Chart

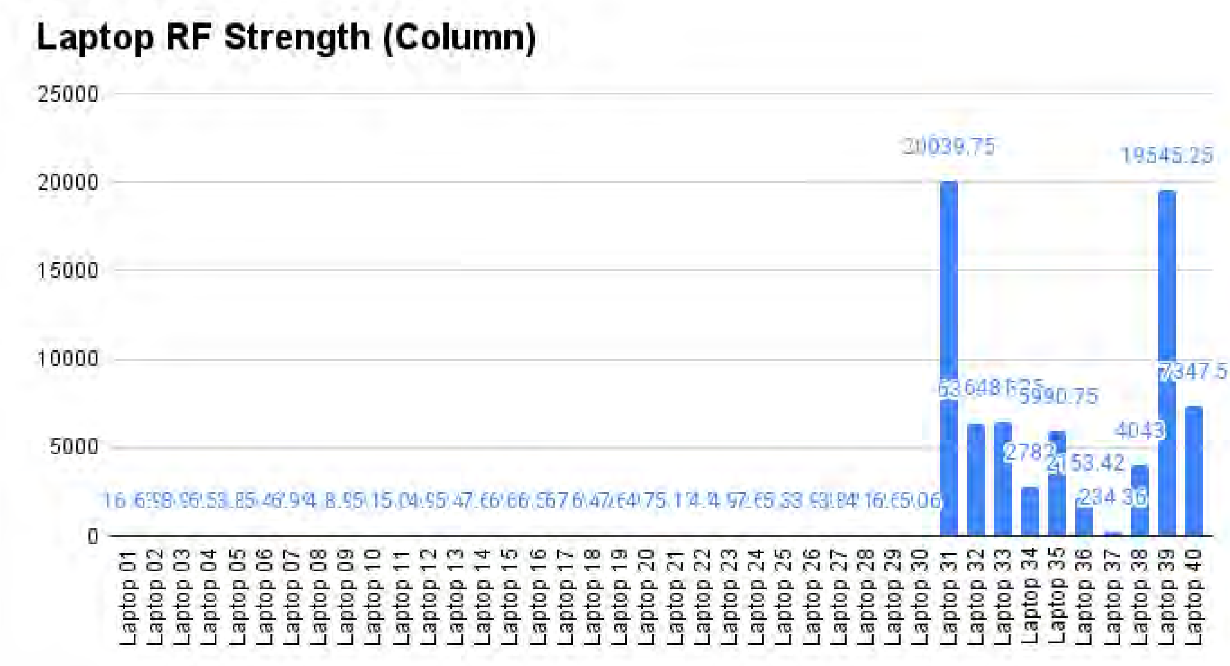

Figure 87: Laptop RF Strength (µW/m²) Column Chart

We gathered information from 40 laptops. The data was displayed as a bar and column chart in the graph. Nearly 10 µW/m² was the lowest emission. Additionally, the majority of the RF strength emissions were near 7500 µW/m². The highest emissions ever measured were 20039.75 µW/m².

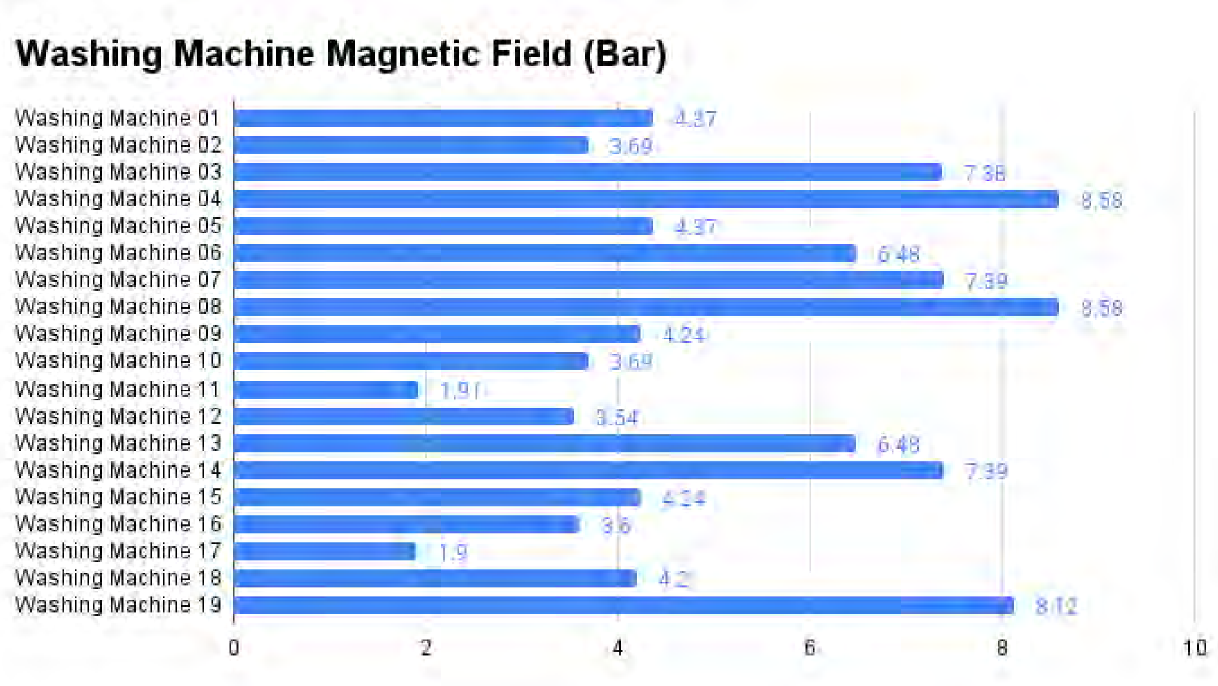

Figure 88: Washing Machine Magnetic Field (mG) Bar Chart

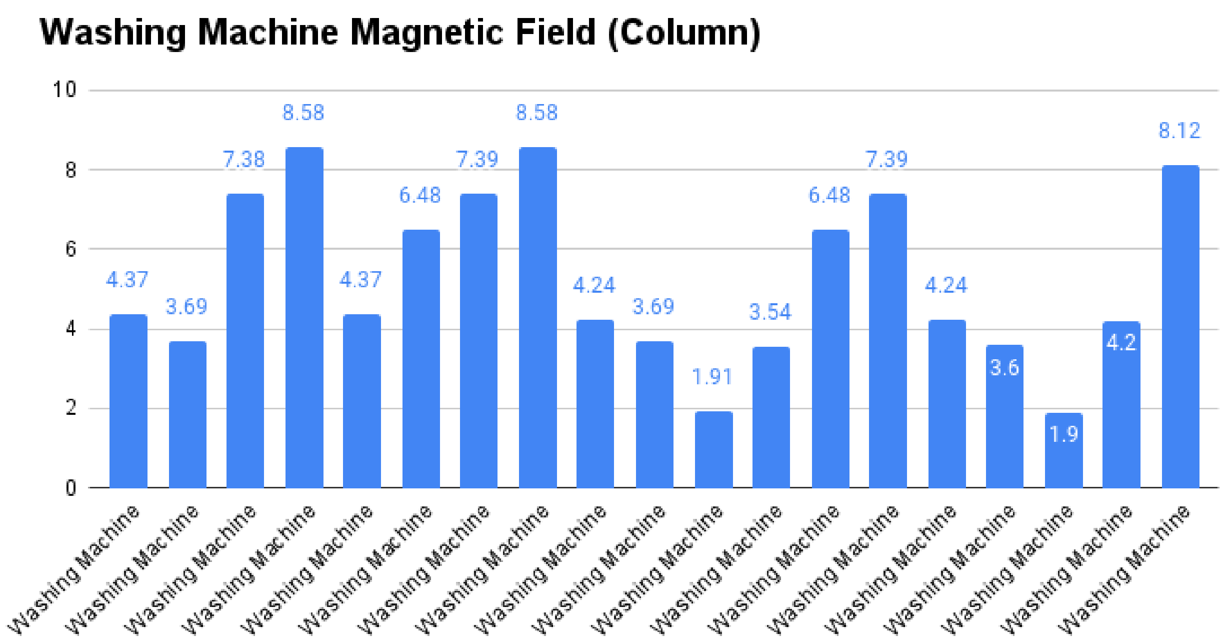

Figure 89: Washing Machine Magnetic Field (mG) Column Chart

Data on magnetic field emissions was gathered from 19 washing machines. We can observe that the emissions were somewhat near to one another. The strongest observed magnetic field emissions were 8.58 milli Gauss (mG).

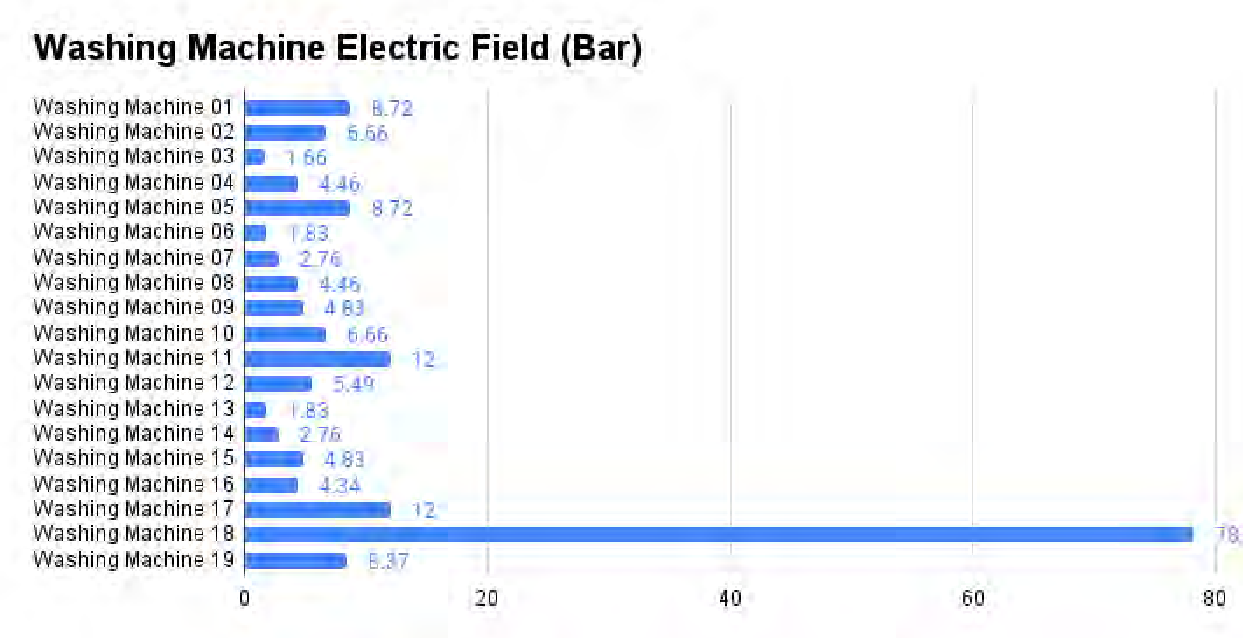

Figure 90: Washing Machine Electric Field (V/m) Bar Chart

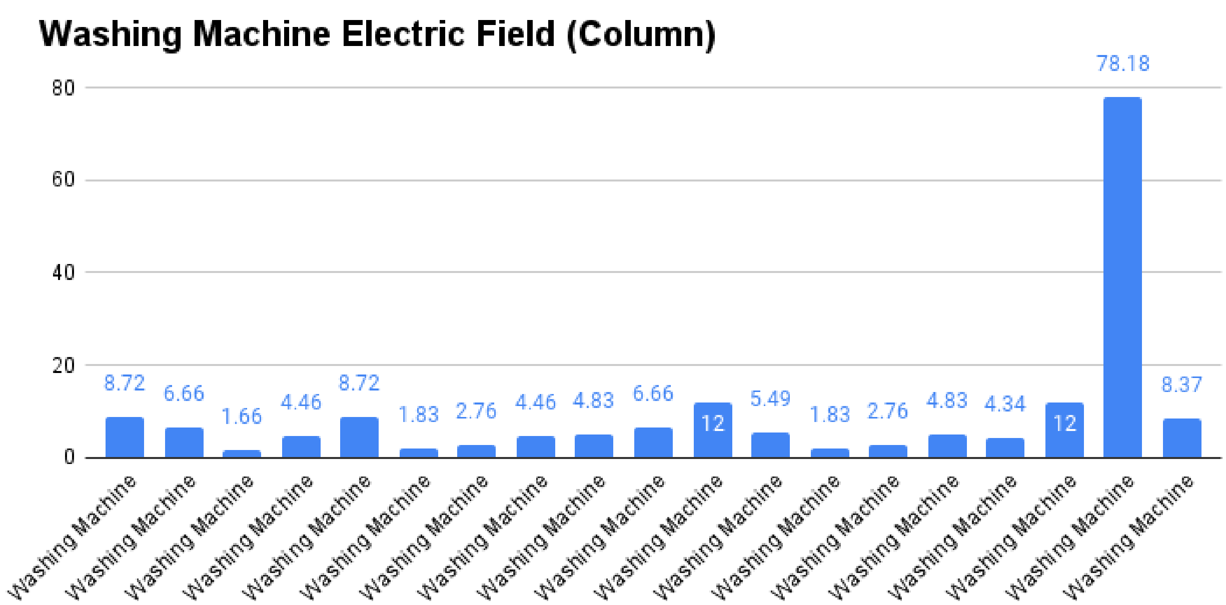

Figure 91: Washing Machine Electric Field (V/m) Column Chart

We gathered information on electric field emissions from 19 washing machines. The majority of the readings are below 10 V/m, as can be shown. Emissions of the strongest electric field were measured at 78.18 V/m.

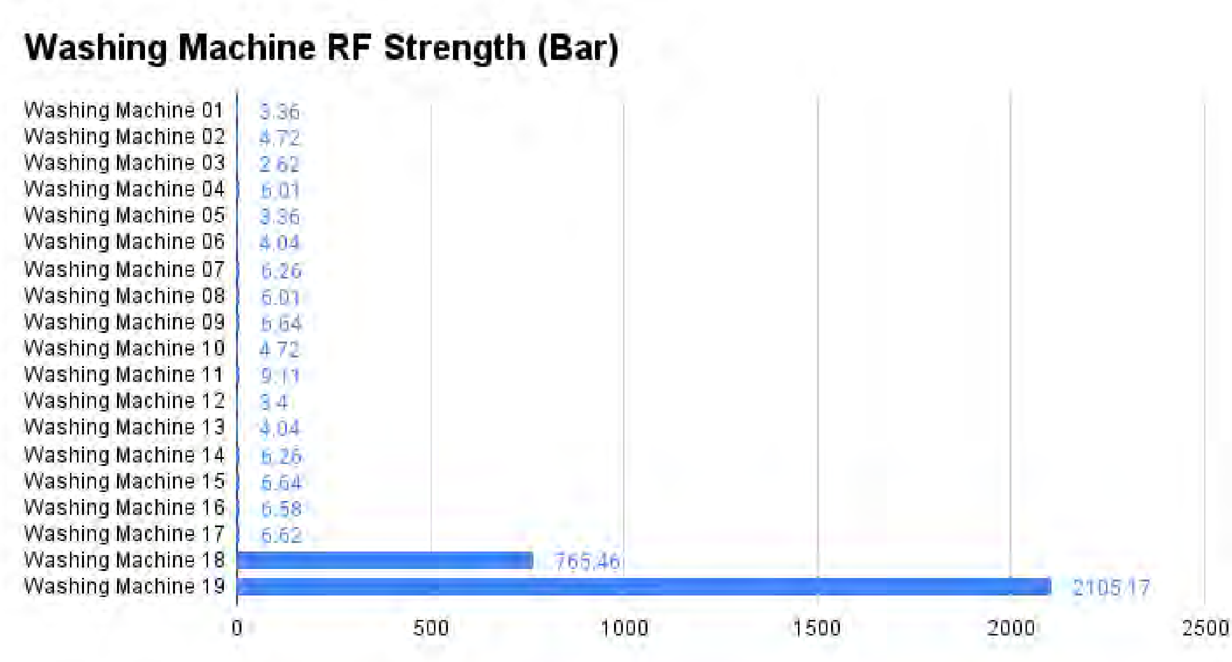

Figure 92: Washing Machine RF Strength (µW/m²) Bar Chart

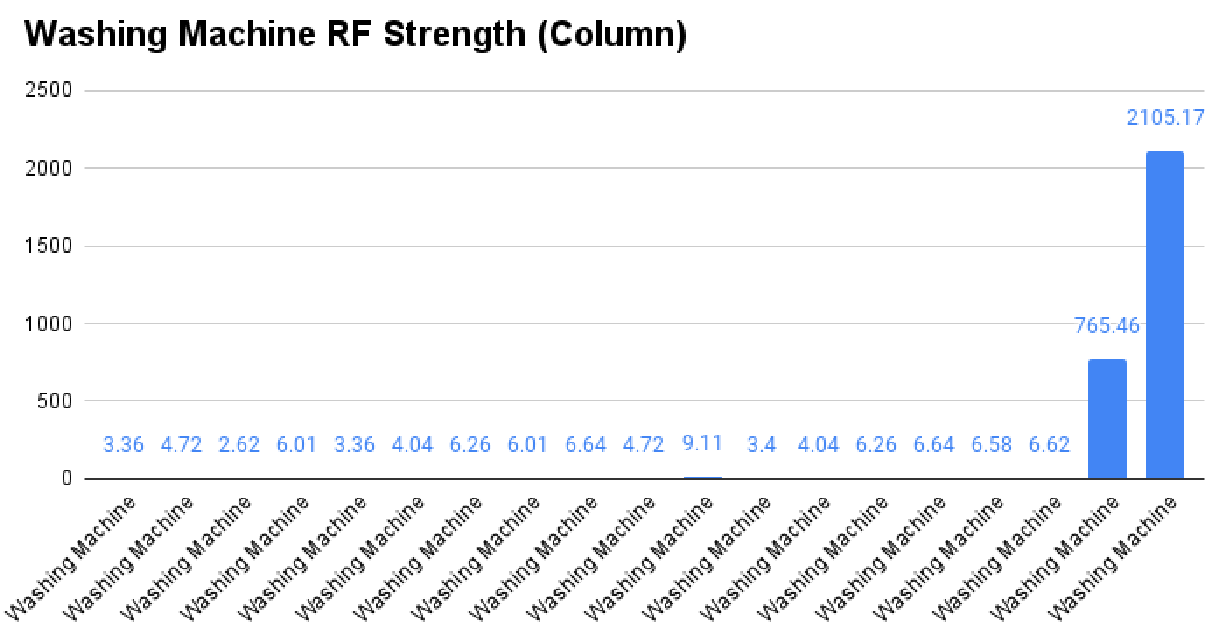

Figure 93: Washing Machine RF Strength (µW/m²) Column Chart

The RF strength emissions from 19 washing machines were gathered. Both a bar chart and a column chart were used to display the data. The majority of washing machines emit less than 10 µW/m². And the emissions with the maximum RF strength were 2105.17 µW/m².

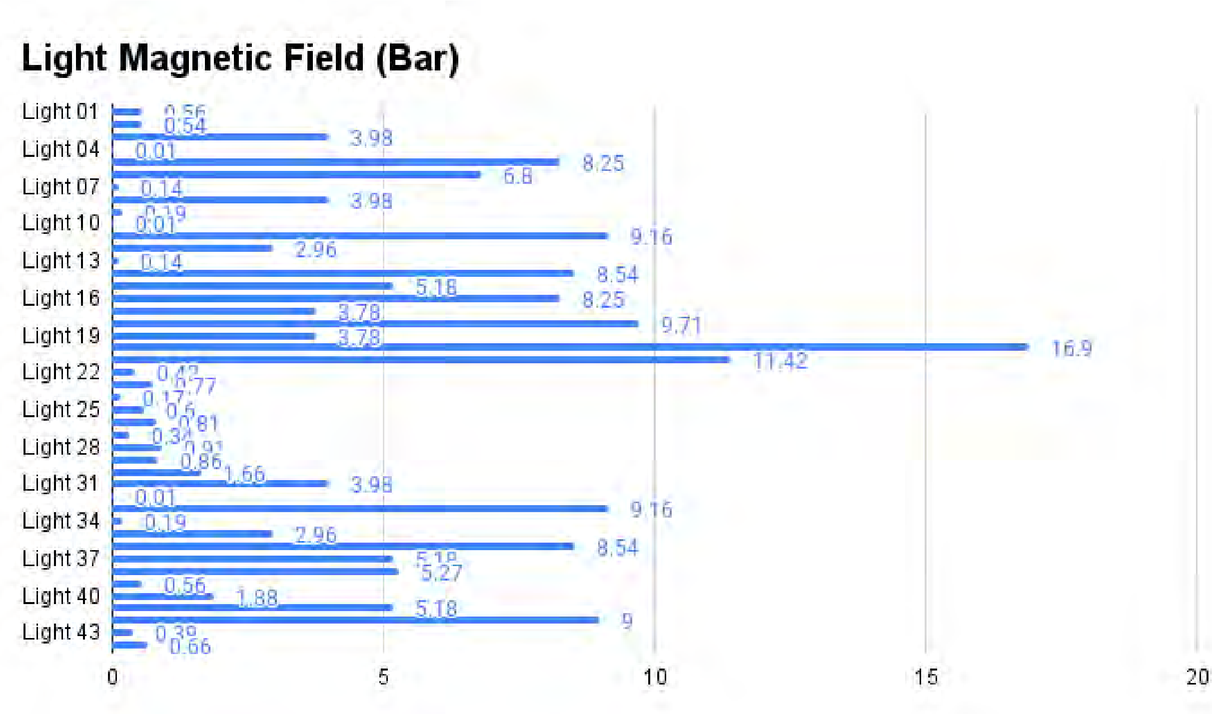

Figure 94: Light Magnetic Field (mG) Bar Chart

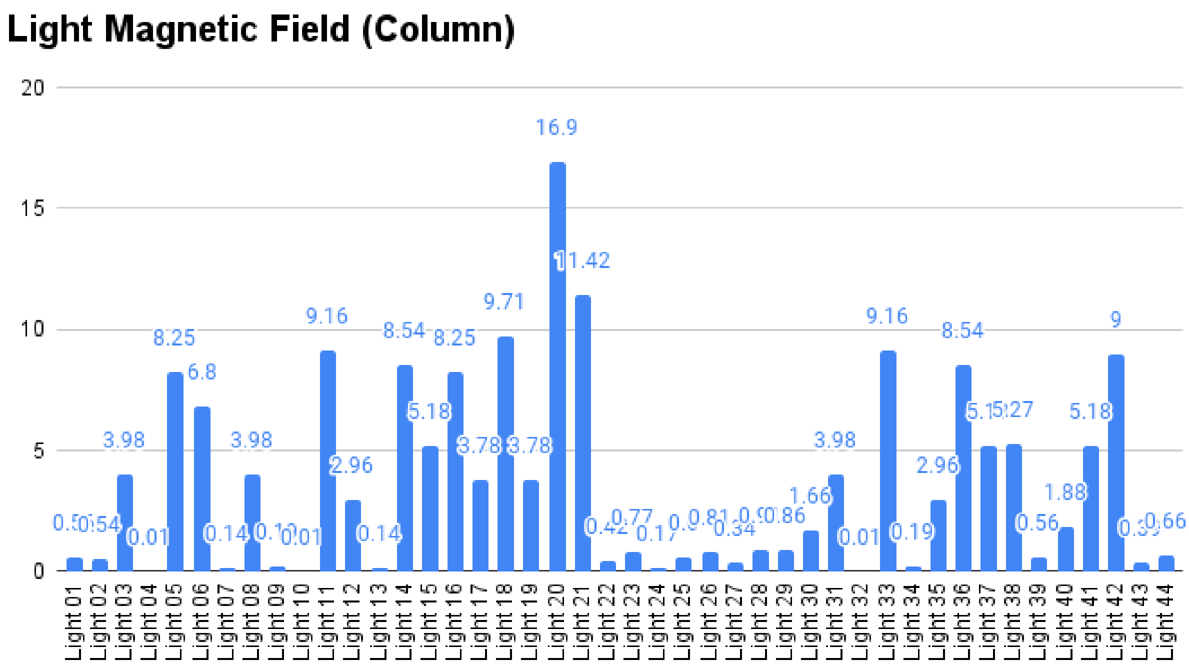

Figure 95: Light Electric Field (V/m) Column Chart

We gathered information about magnetic field emissions from forty-four lamps. A bar chart and a column chart were used to display the data. We are able to observe the variations in magnetic field emissions. Light emits the lowest magnetic field, 0.01 milli Gauss (mG). Additionally, the strongest magnetic field emissions were measured at 16.9 milli Gauss (mG).

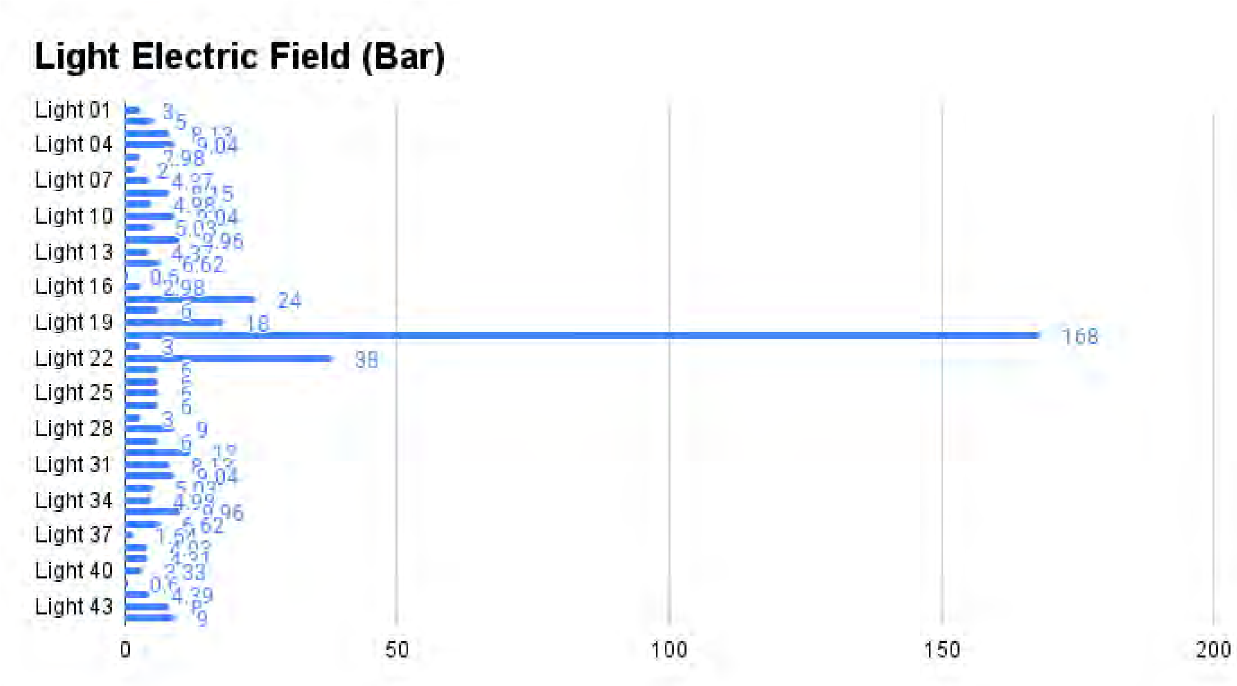

Figure 96: Light Electric Field (V/m) Bar Chart

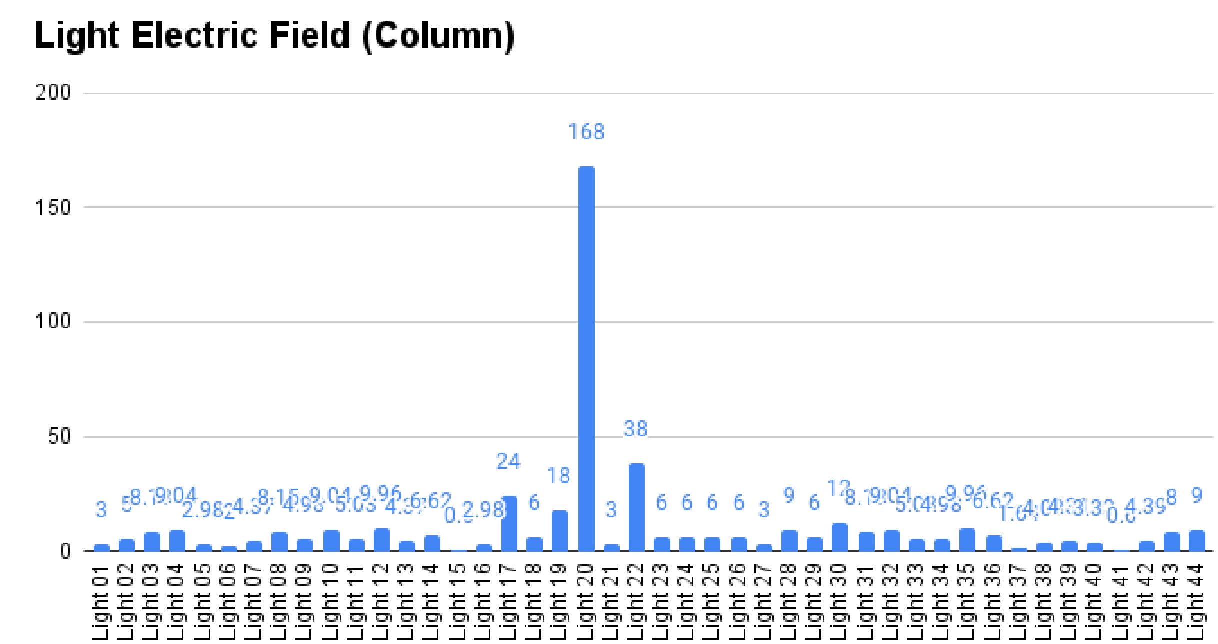

Figure 97: Light Electric Field (V/m) Column Chart

We gathered information on the electric field emissions from 44 lights. A bar chart and a column chart were used to display the data on the graph. Most of the electric field emission fluctuations are visible. Emissions of magnetic fields from light range from 0.5 V/m at the lowest to 168 V/m at the maximum.

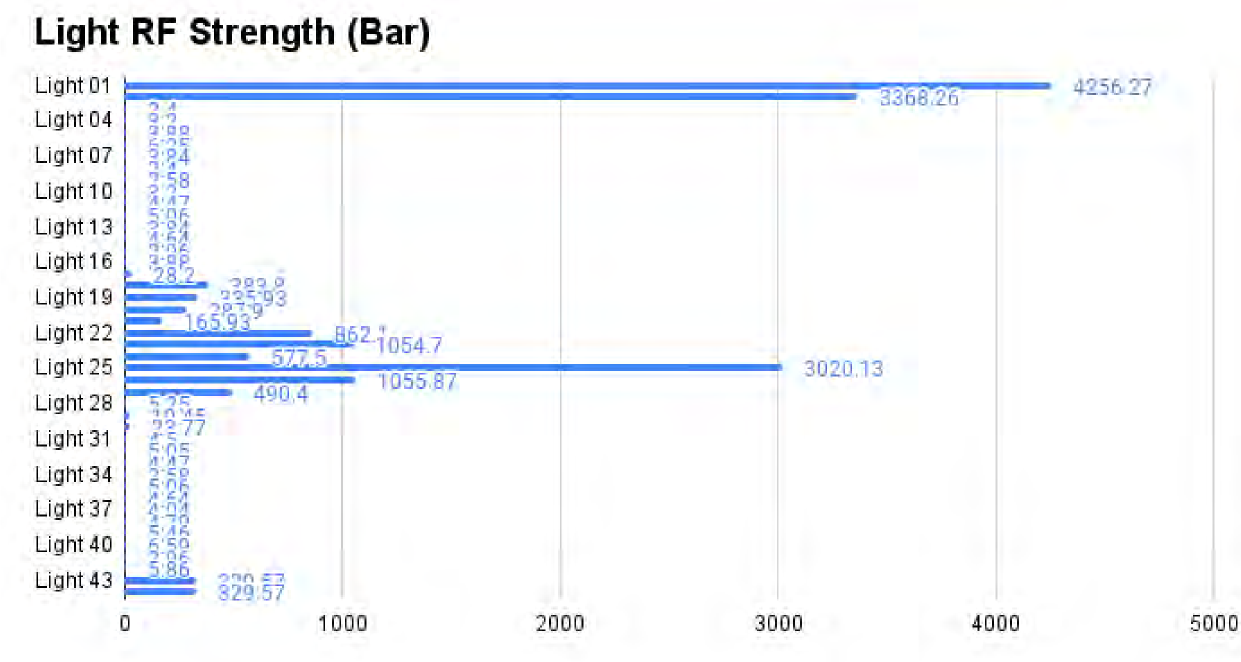

Figure 98: Light RF Strength (µW/m²) Bar Chart

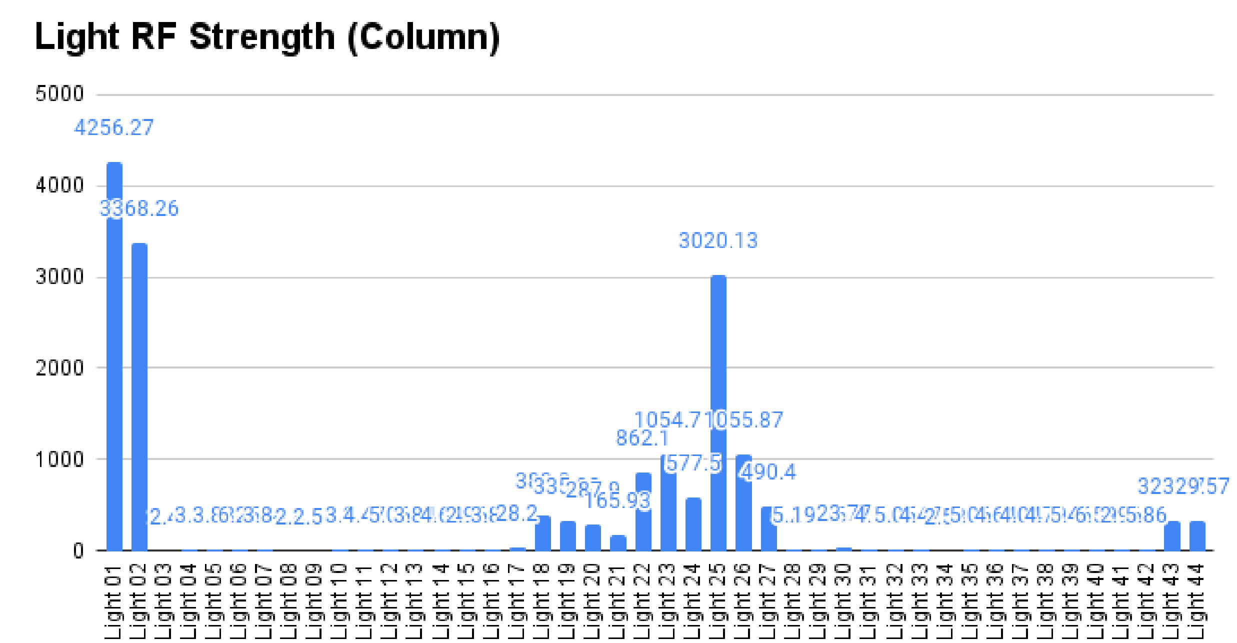

Figure 99: Light RF Strength (µW/m²) Column Chart

We gathered information on 44 lights' RF strength emissions. A bar chart and a column chart were used to display the data on the graph.Light has the lowest RF strength emissions, at 3.5 µW/m². The highest observed emissions of RF strength were 3020.14 µW/m².

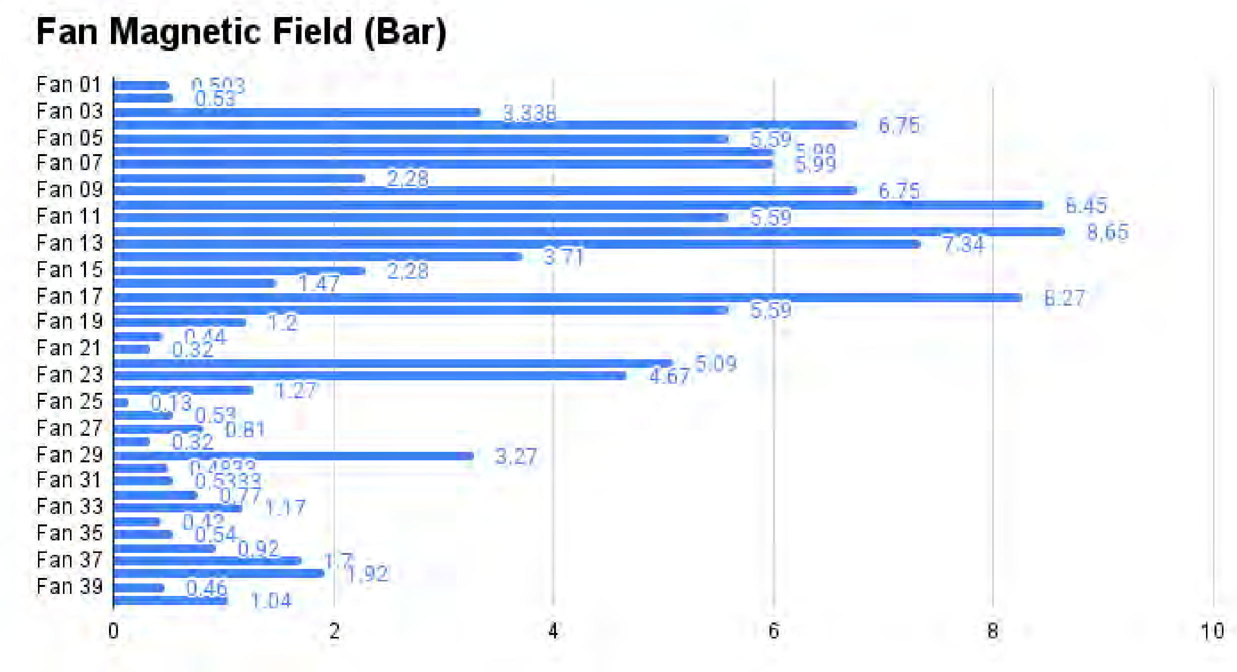

Figure 100: Fan Magnetic Field (mG) Bar Chart

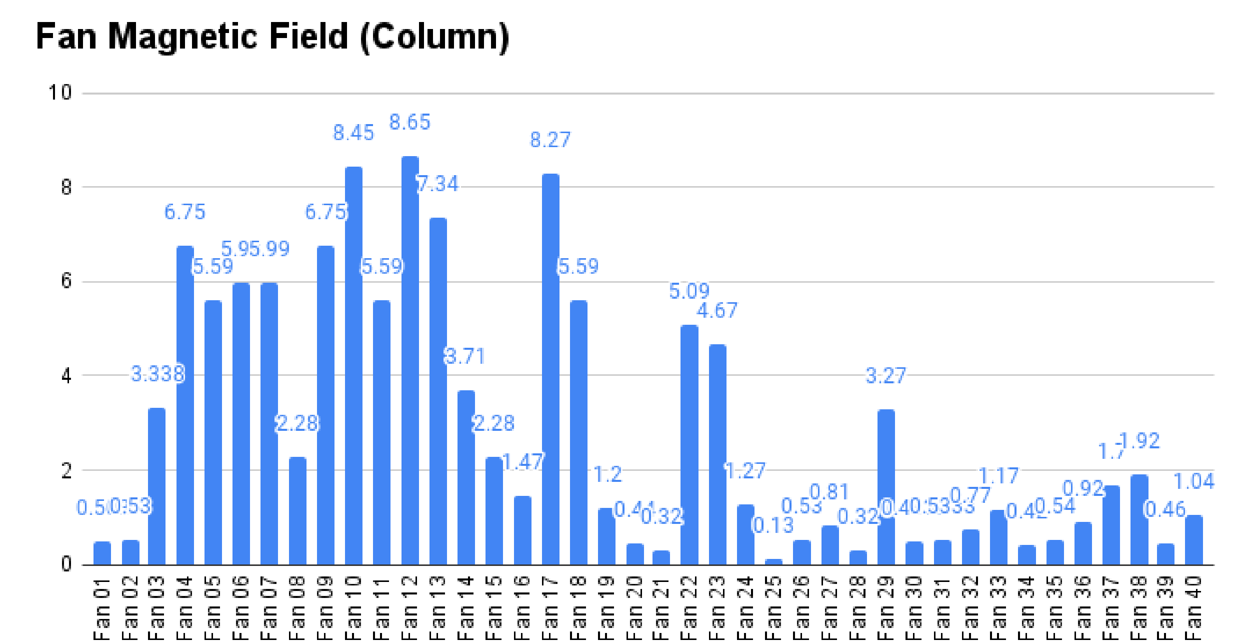

Figure 101: Fan Magnetic Field (mG) Column Chart

We gathered information on the magnetic field emissions from 40 fans. A bar chart and a column chart were used to display the data on the graph. The graph shows the emissions fluctuation.The strongest observed magnetic field outputs were 8.65 milli Gauss (mG).

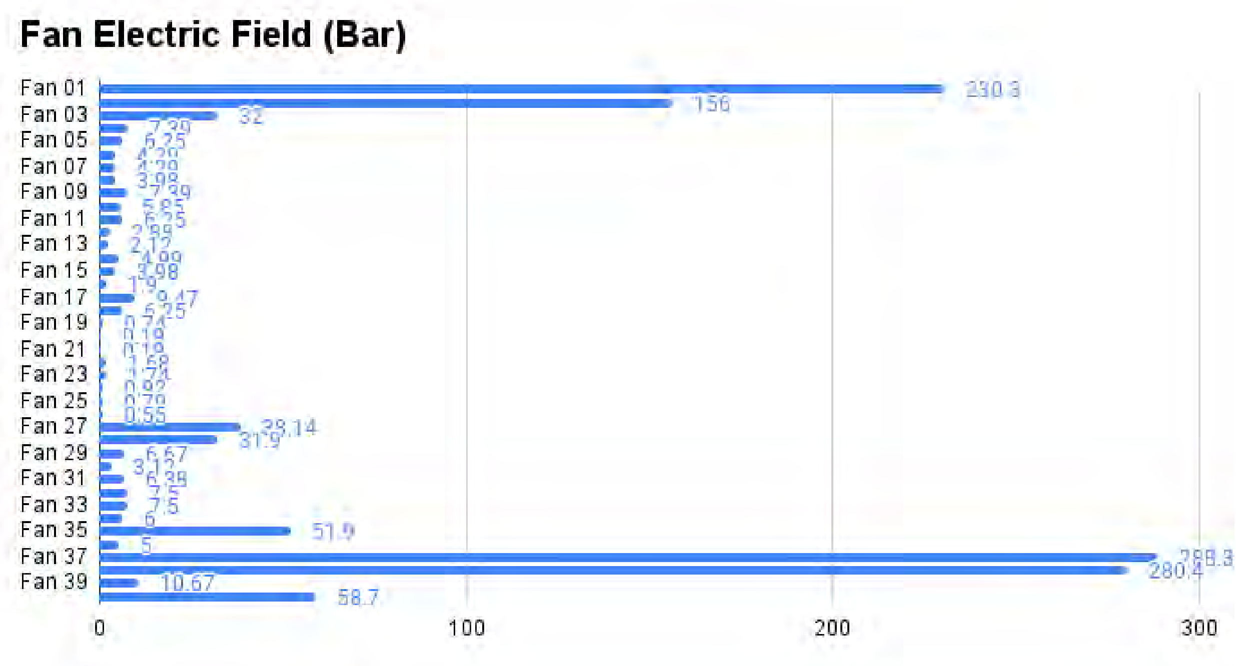

Figure 102: Fan Electric Field (V/m) Bar Chart

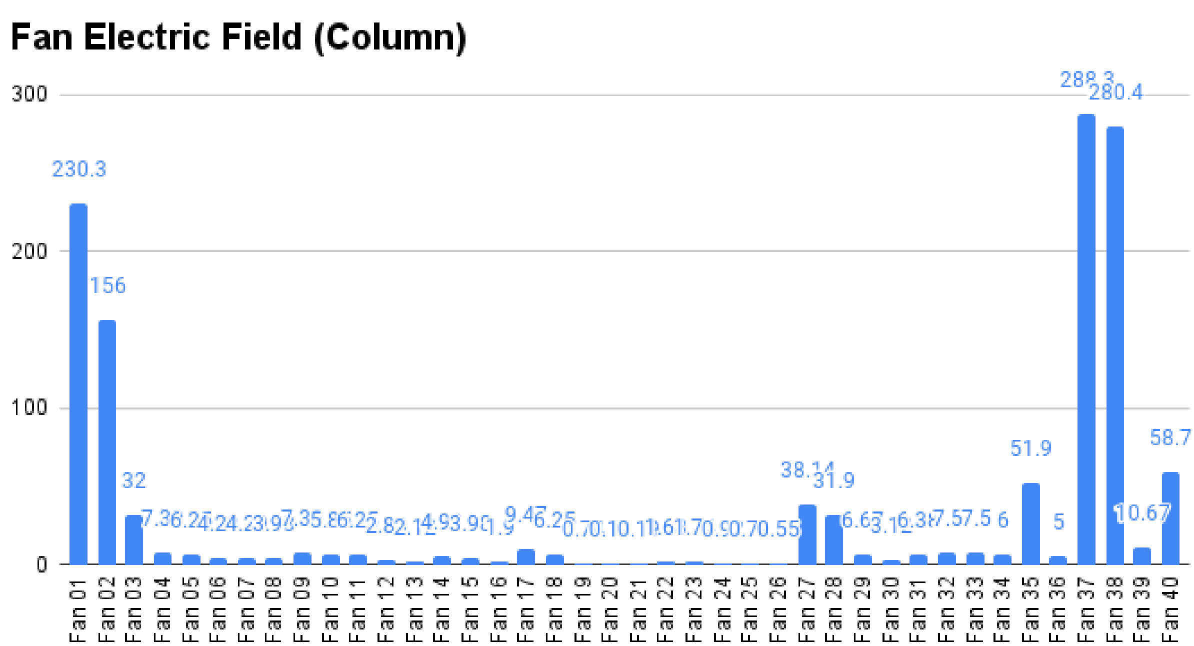

Figure 103: Fan Electric Field (V/m) Column Chart

From 40 fans, we gathered data on electric field emissions. Both a bar chart and a column chart were used to display the data. In the graph, the emissions volatility is obvious. Emissions from the lowest electric field were 0.19 V/m.The largest outputs of electric fields were measured at 288.3 V/m.

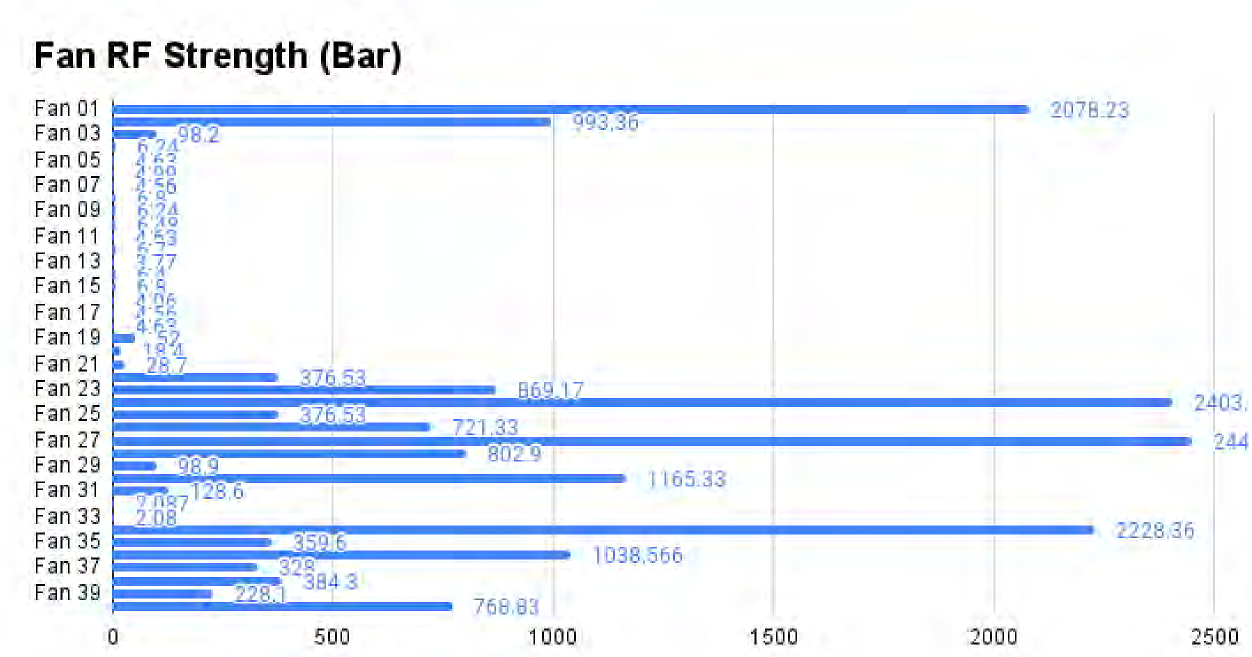

Figure 104: Fan RF Strength (µW/m²) Bar Chart

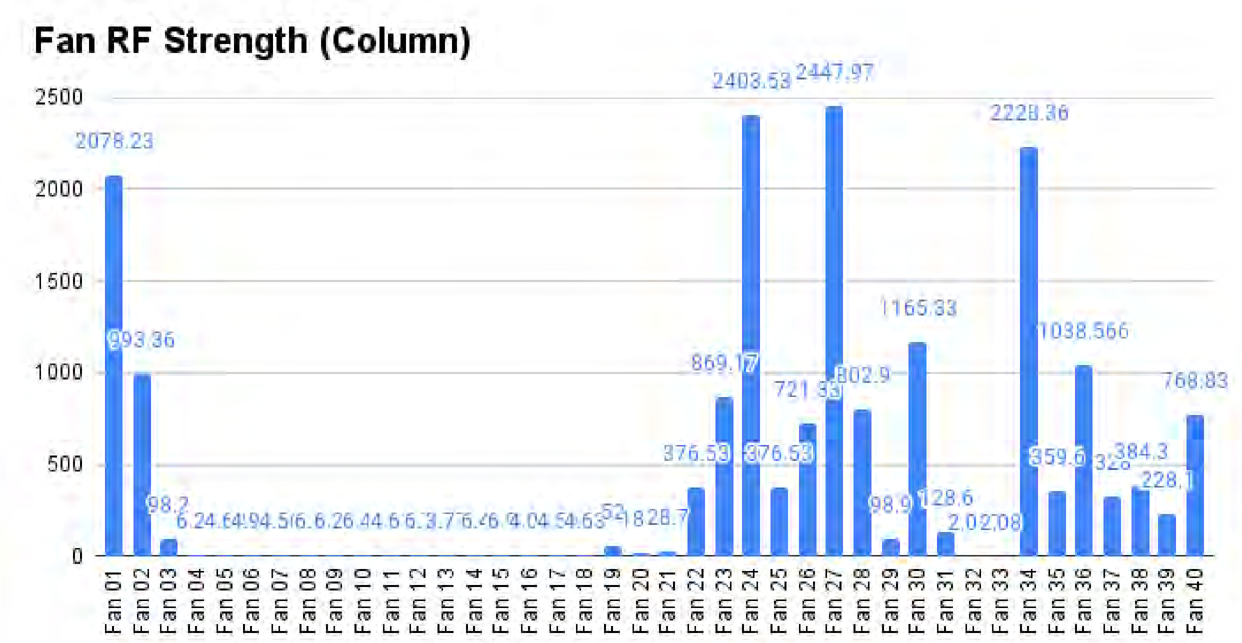

Figure 105: Fan RF Strength (µW/m²) Column Chart

Data on RF strength emissions from 40 fans was gathered. Both a bar chart and a column chart were used to display the data. In the graph, the emissions volatility is obvious.At 4.00 µW/m2, the lowest electric field emissions were recorded.The maximum electric field emissions, 2447.97 µW/m2, were measured.

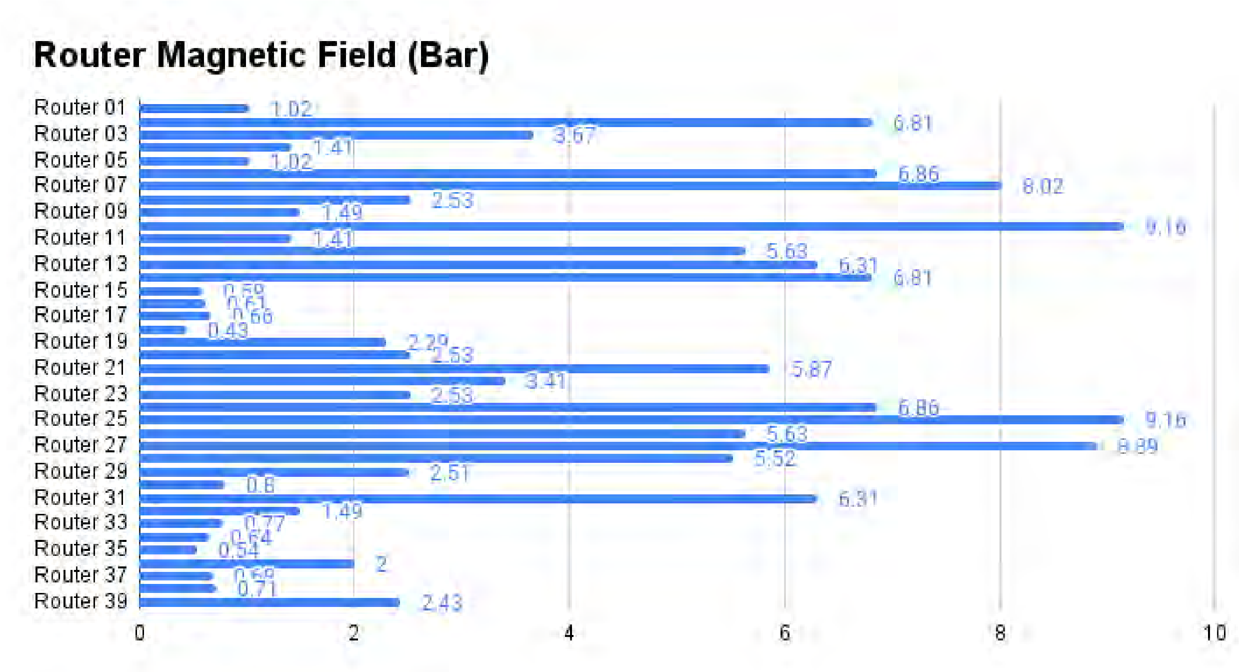

Figure 106: Router Magnetic Field (mG) Bar Chart

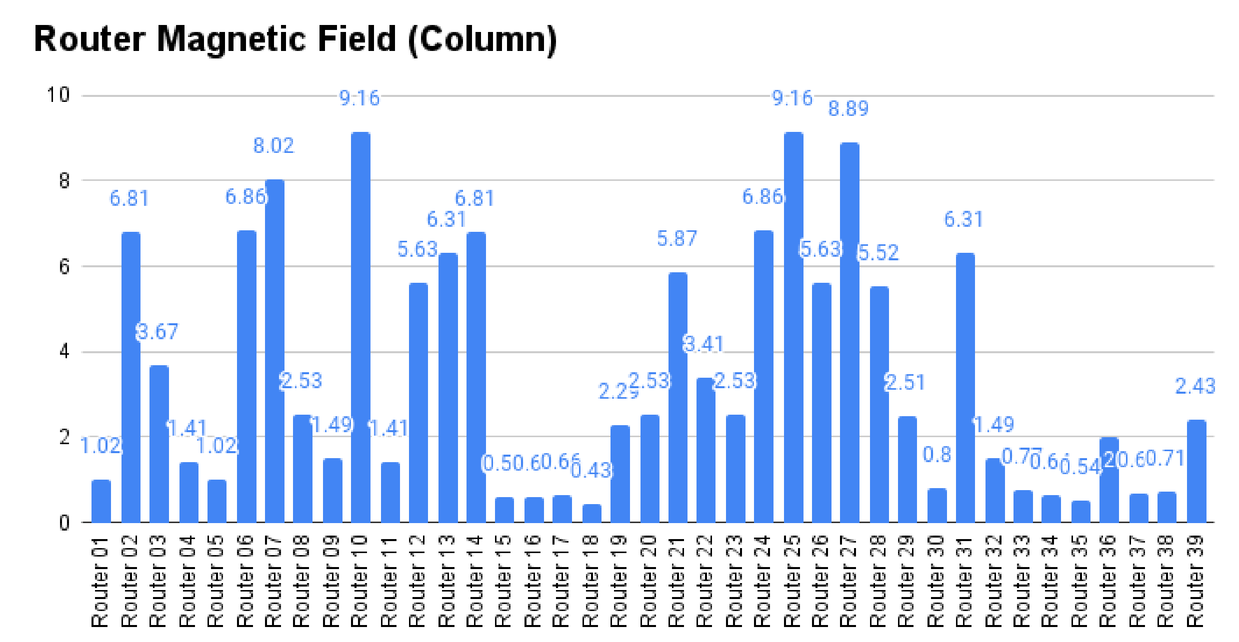

Figure 107: Router Magnetic Field (mG) Column Chart

We gathered magnetic field emissions data from 39 routers. A bar chart and a column chart were used to display the data on the graph. The graph shows the emissions fluctuation.Emissions from the lowest magnetic field were detected at 0.43 milli Gauss (mG).The strongest observed magnetic field outputs were 9.16 milli Gauss (mG).

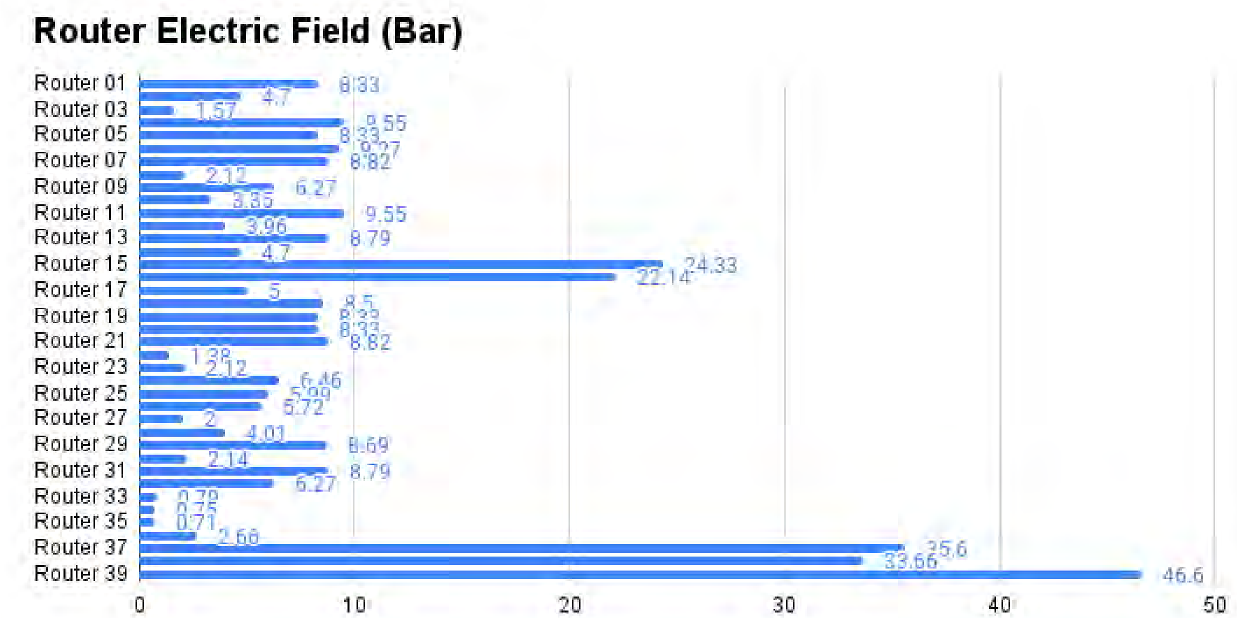

Figure 108: Router Electric Field (V/m) Bar Chart

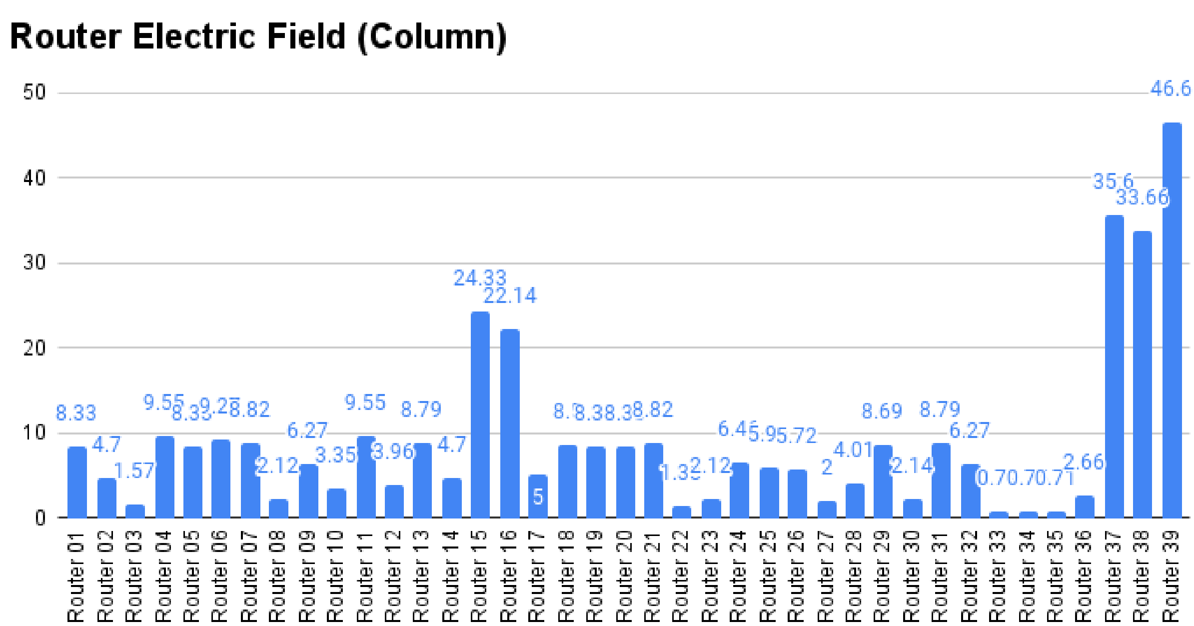

Figure 109: Router Electric Field (V/m) Column Chart

We gathered electric field emissions data from 39 routers. A bar chart and a column chart were used to display the data on the graph. The graph shows the emissions fluctuation.0.70 V/m was found to be the lowest magnetic field emissions.Emissions of the strongest electric field were measured at 46.6 V/m.

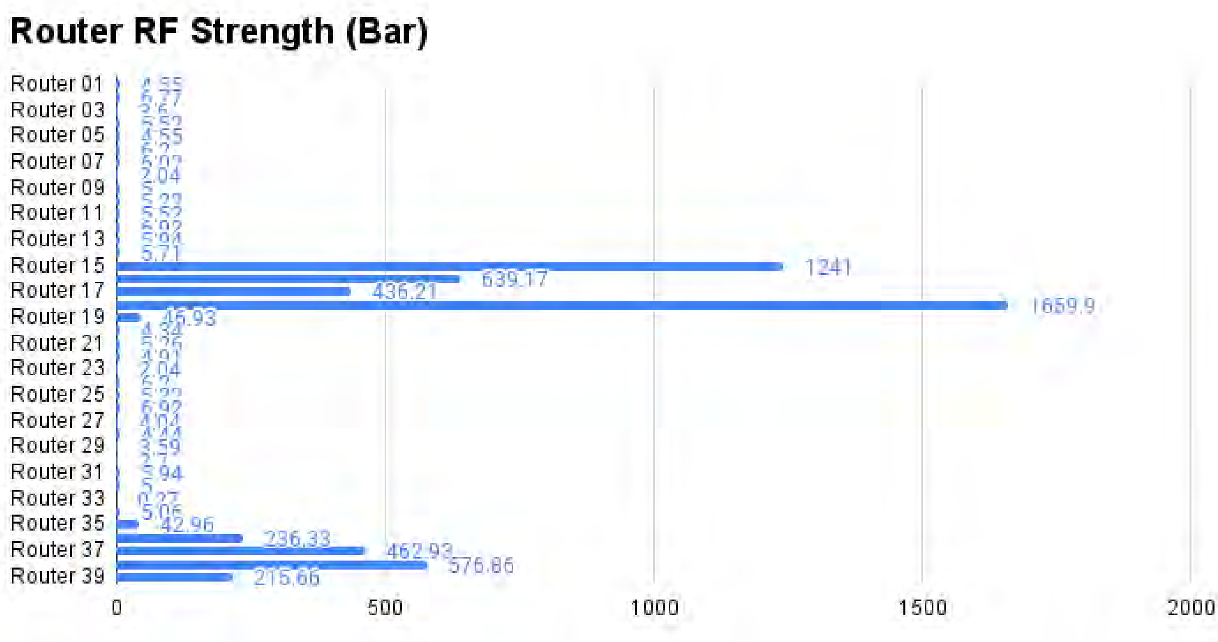

Figure 110: Router RF Strength (µW/m²) Bar Chart

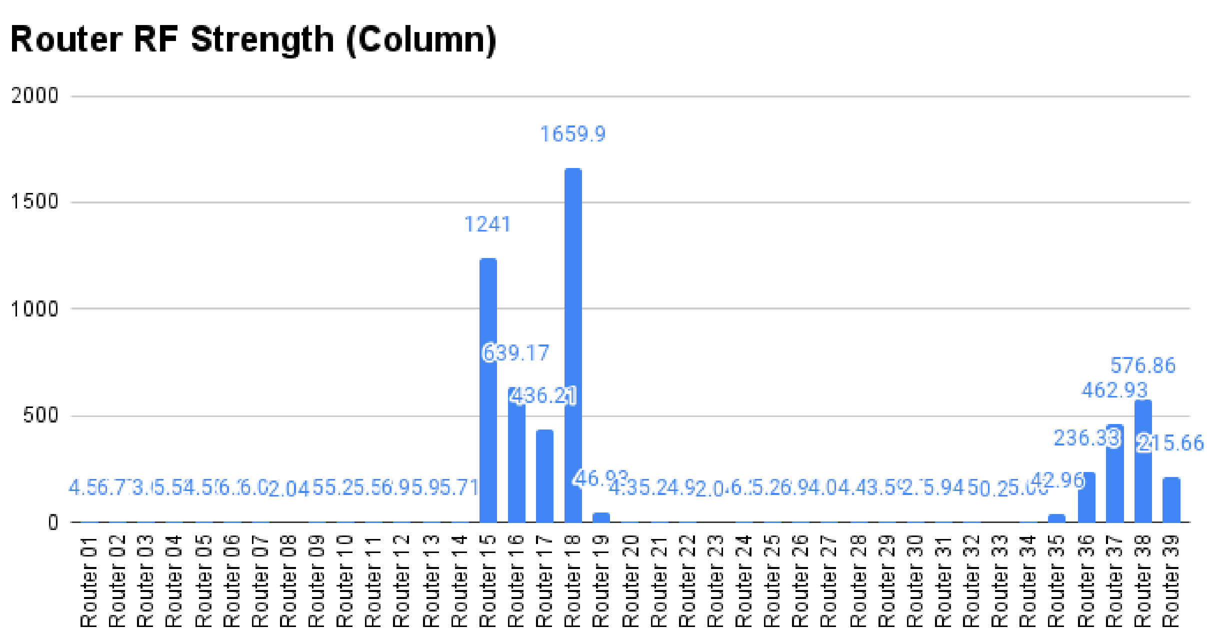

Figure 111: Router RF Strength (µW/m²) Column Chart

Data on electric field emissions was gathered from 39 routers. Both a bar chart and a column chart were used to display the data. In the graph, the emissions volatility is obvious.The emissions with the lowest RF strength were found to be 0.2 µW/m2.The highest emissions of radiofrequency strength were measured at 1659.9 µW/m2.

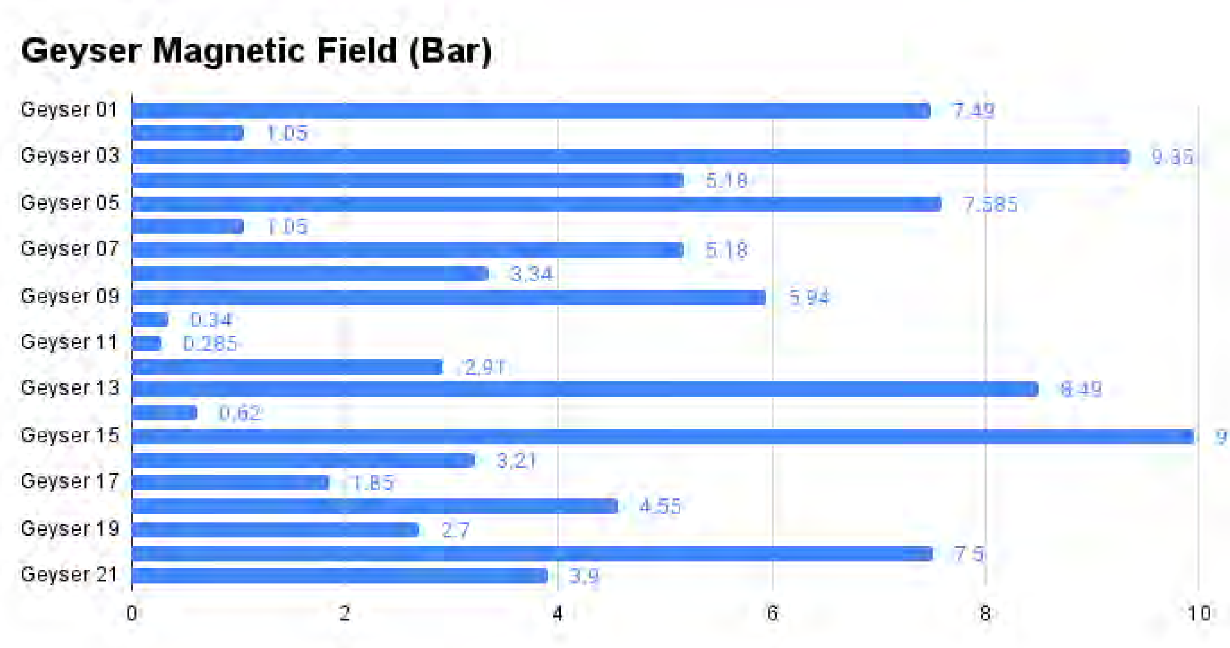

Figure 112: Geyser Magnetic Field (mG) Bar Chart

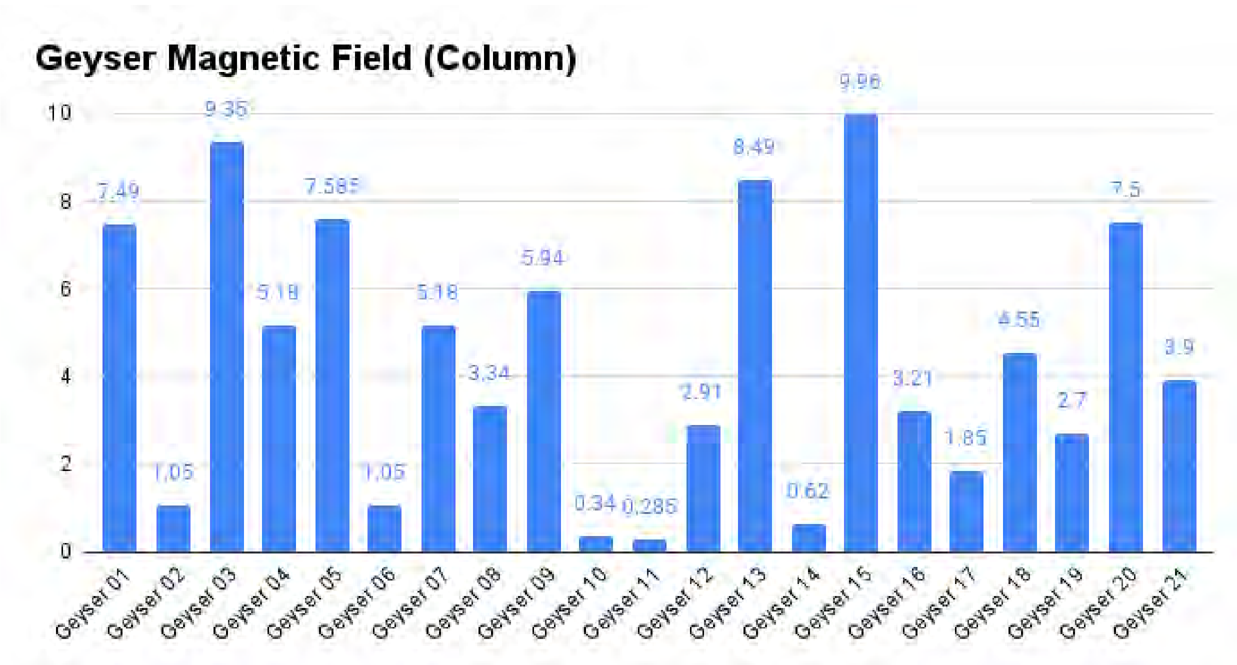

Figure 113: Geyser Magnetic Field (mG) Column Chart

From 21 geysers, we gathered data on magnetic field emissions. Both a bar chart and a column chart were used to display the data. The lowest observed magnetic field emissions in this instance are 0.285 milli Gauss (mG). The emissions' fluctuation is visible to us. The strongest magnetic field emissions, 9.96 mG, are detected.

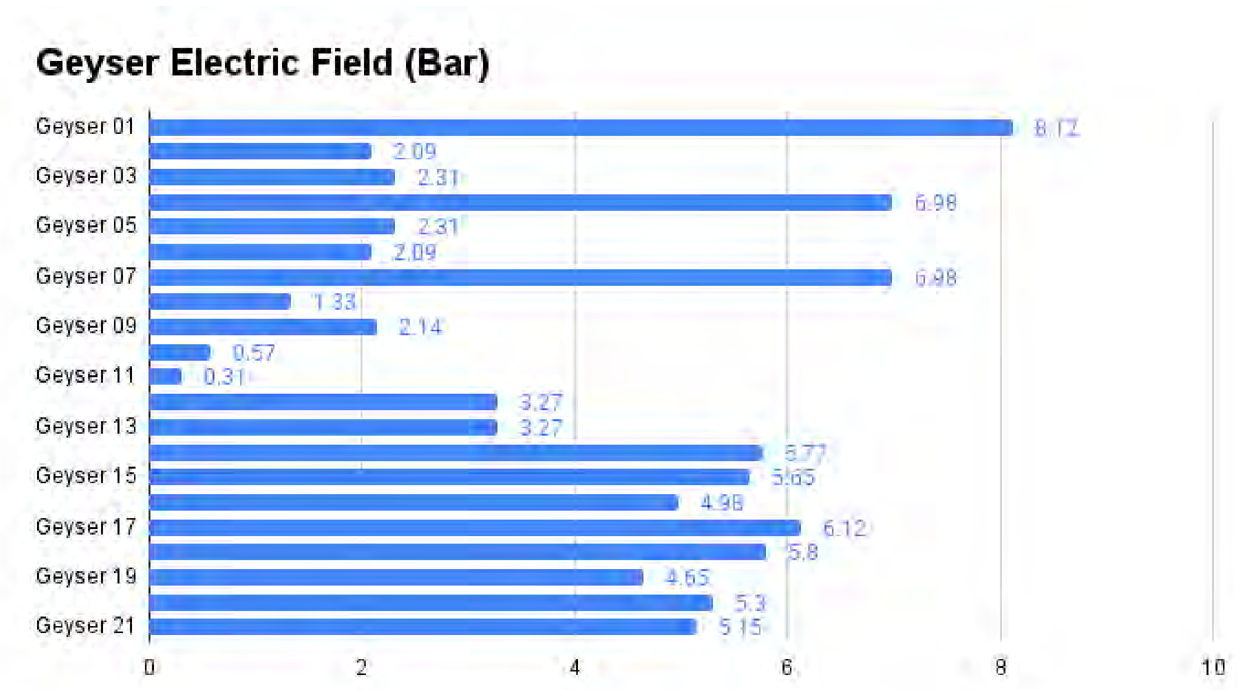

Figure 114: Geyser Electric Field (V/m) Bar Chart

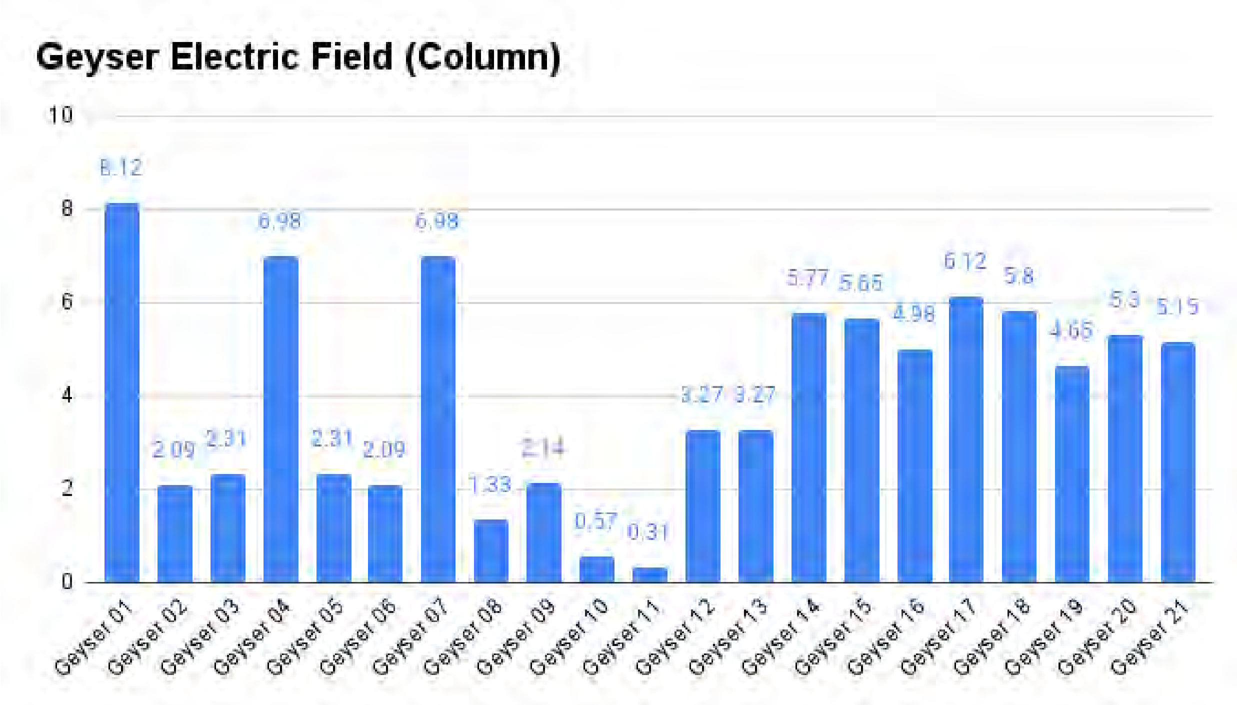

Figure 115: Geyser Electric Field (V/m) Column Chart

We gathered information on 21 geysers' electric field emissions. The graph displayed the data as a column chart and a bar chart. 0.31 V/m is the lowest magnetic field emissions measured here.The emission fluctuation is visible. At 8.12 V/m, the strongest electric field emissions are seen.

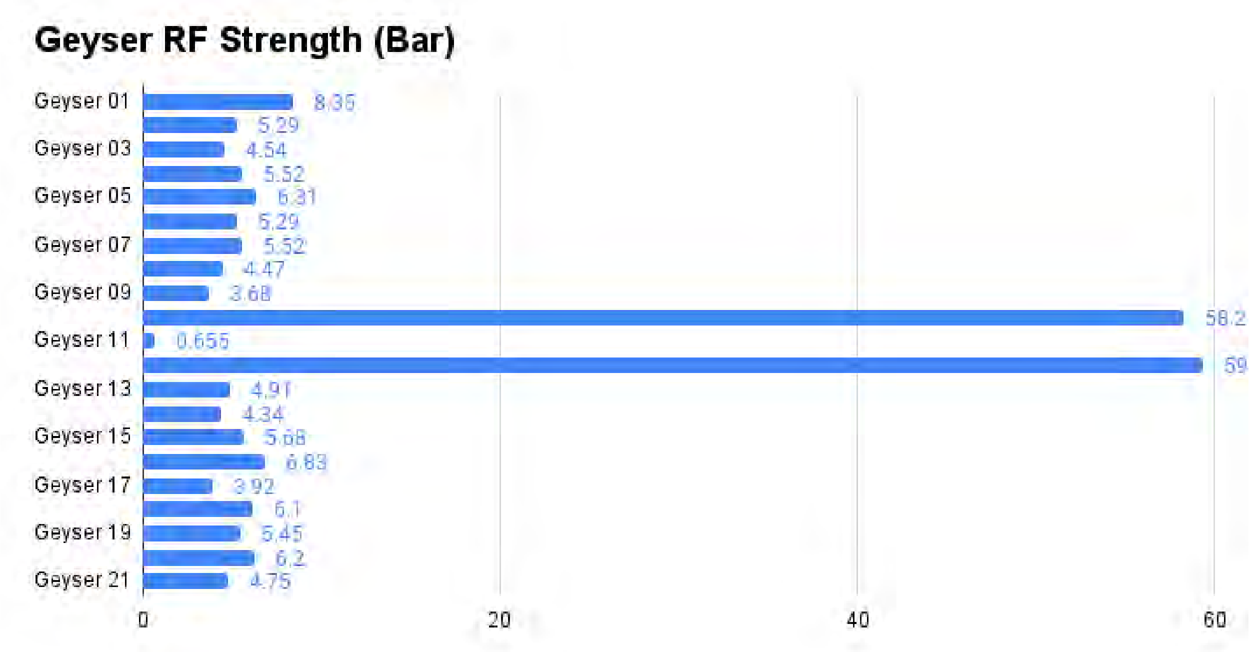

Figure 116: Geyser RF Strength (µW/m²) Bar Chart

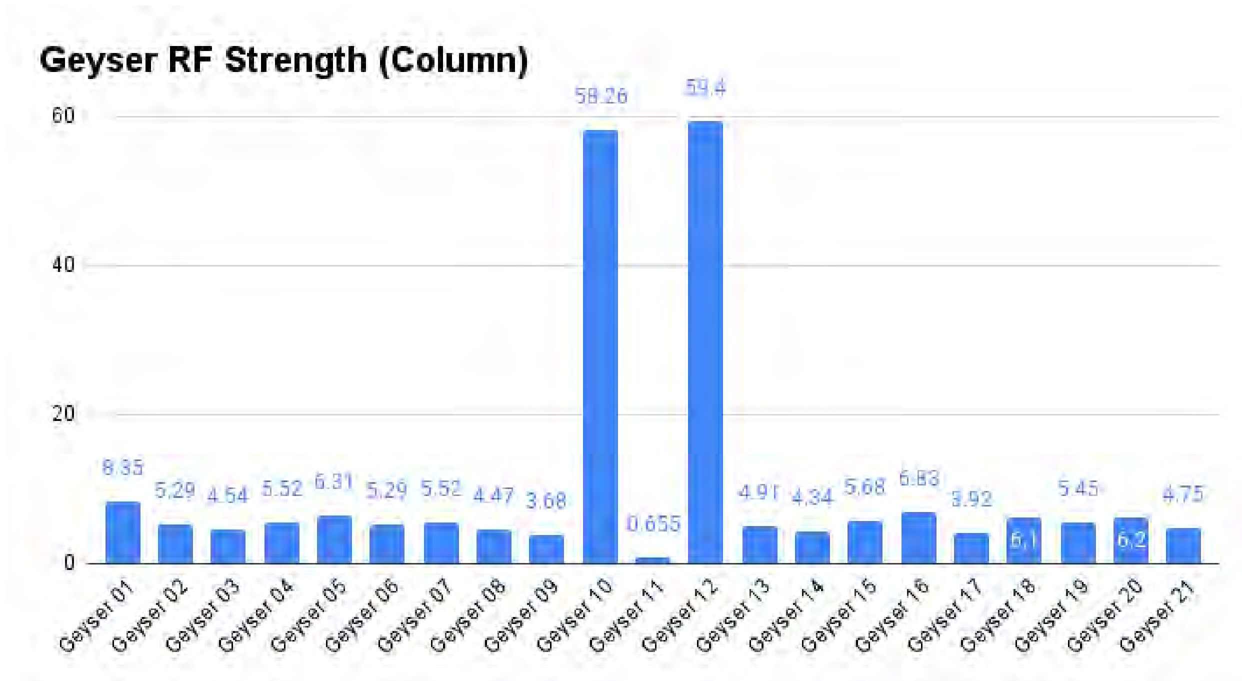

Figure 117: Geyser RF Strength (µW/m²) Column Chart

From 21 geysers, we gathered data on their RF strength emissions. Both a bar chart and a column chart were used to display the data. The lowest reported magnetic field emissions in this instance are 0.655µW/m². The emissions' fluctuation is visible to us. Emissions with an RF strength of 0.6 to 10µW/m² were the most common. The measurement for the greatest RF strength emissions is 59.4µW/m².

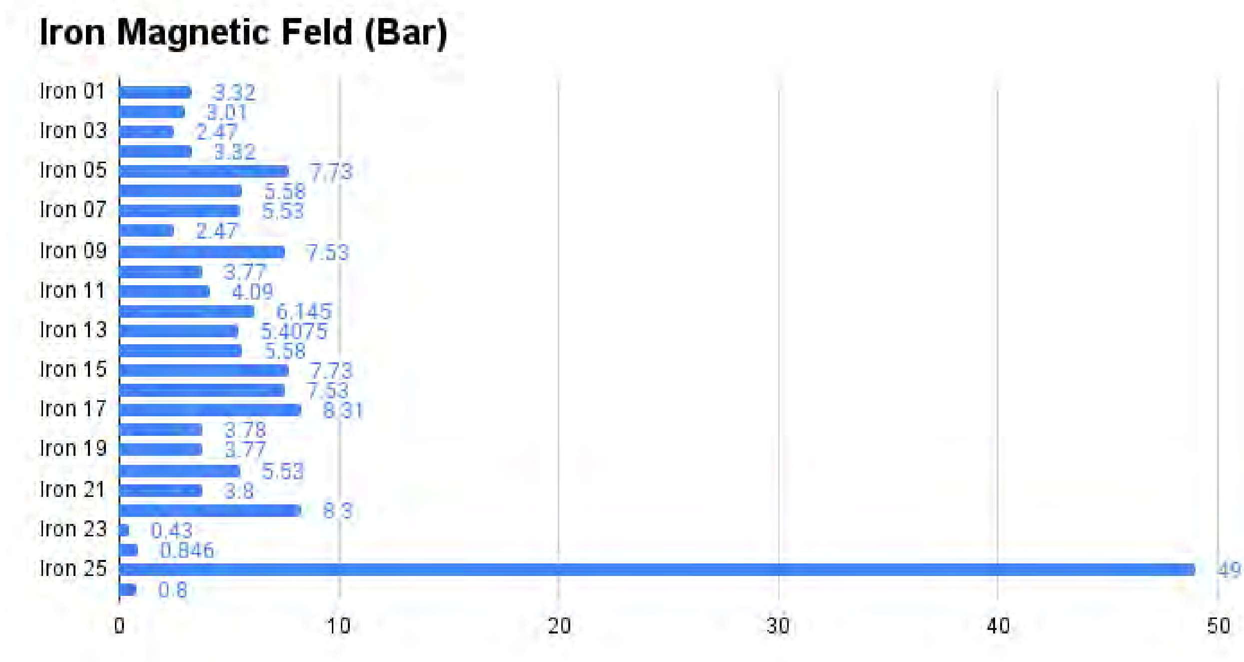

Figure 118 : Iron Magnetic Field (mG) Bar Chart

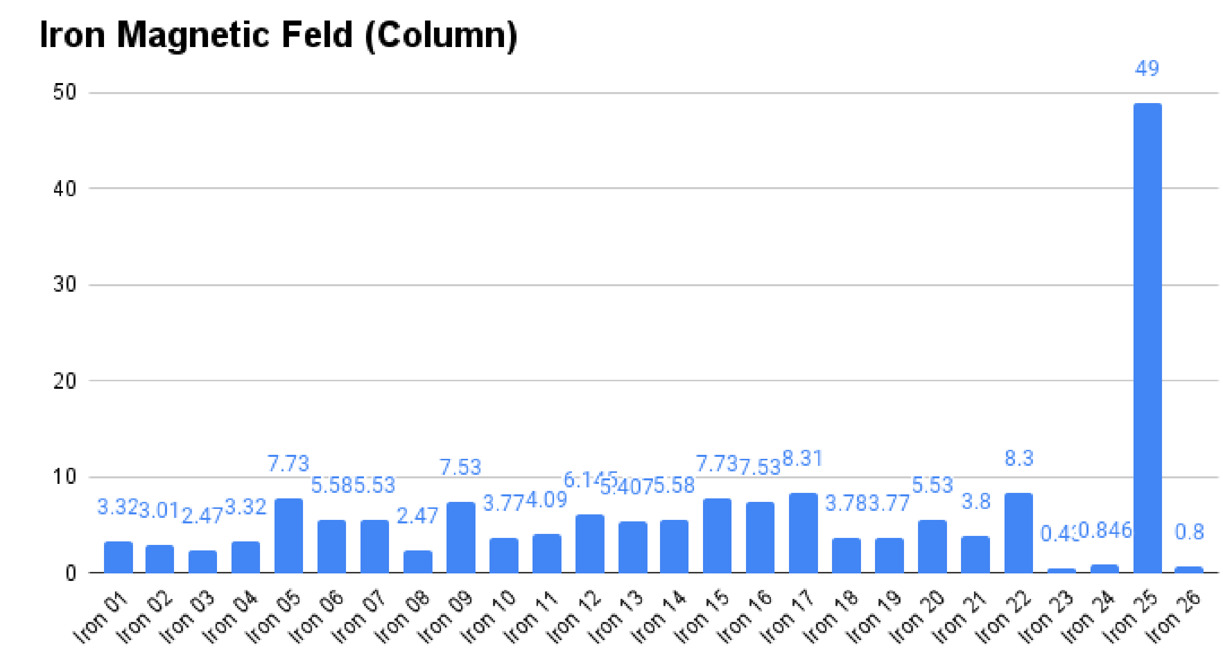

Figure 119: Iron Magnetic Field (mG) Column Chart

Data on magnetic field emissions from 26 irons were gathered. A bar chart and a column chart were used to display the data on the graph. The lowest reported magnetic field emissions in this instance are 0.4 milli Gauss (mG). We can observe the emissions' fluctuation. Emissions of magnetic fields ranged from 0.4 to 8.5 milli Gauss (mG). The maximum observed magnetic field emissions are 49 mG.

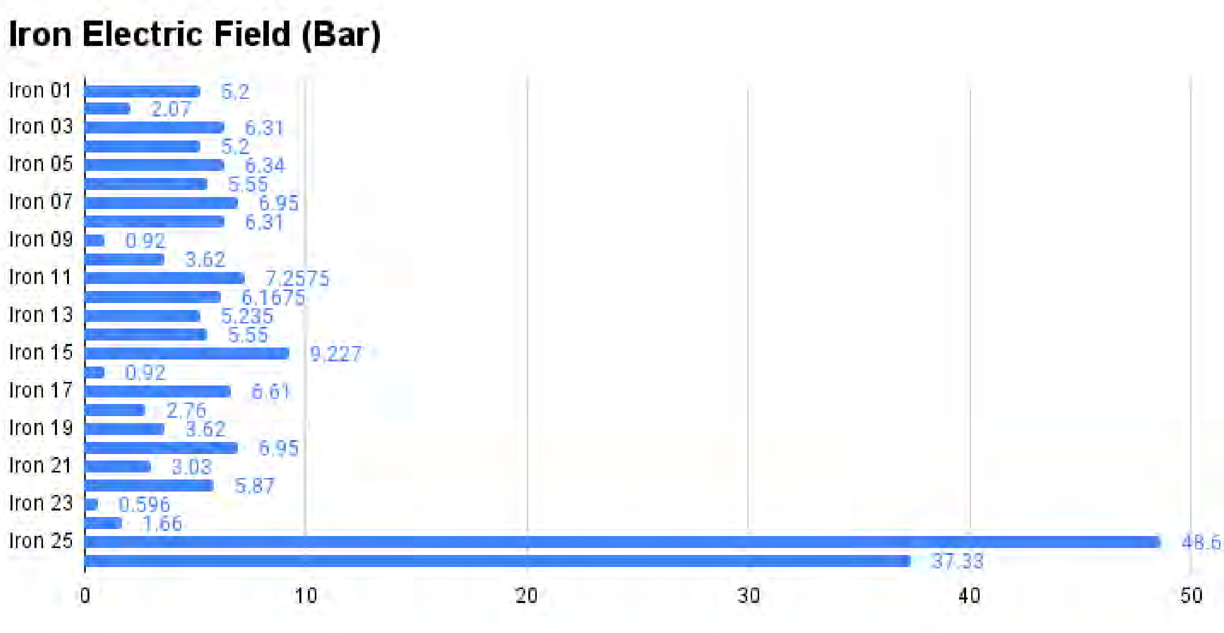

Figure 120: Iron Electric Field (V/m) Bar Chart

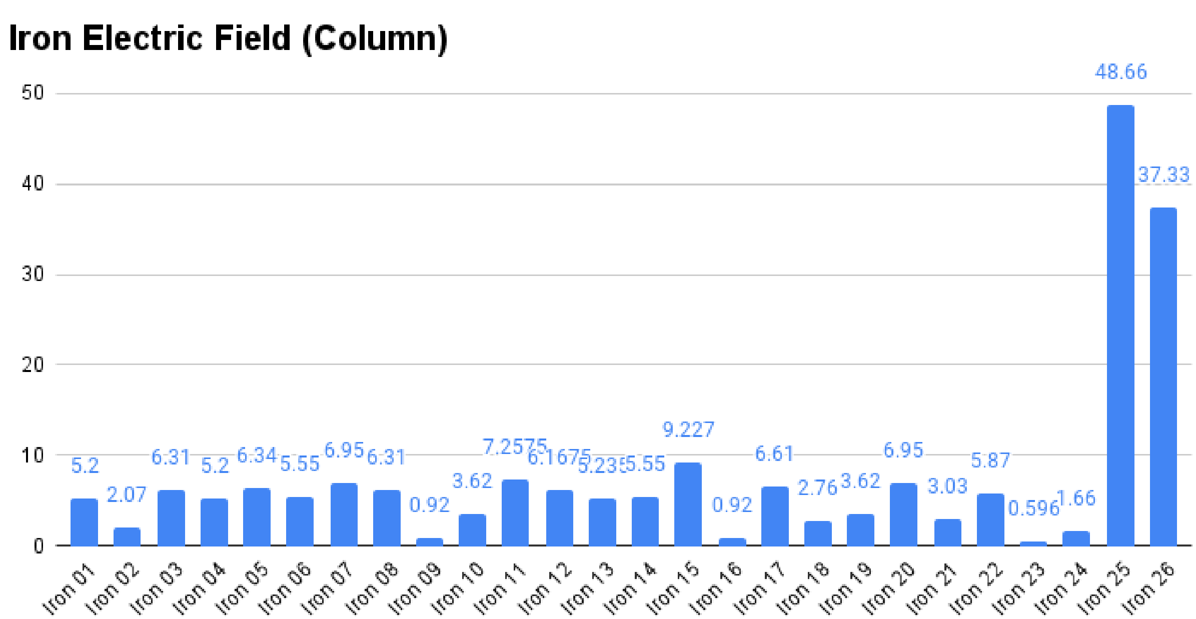

Figure 121: Iron Electric Field (V/m) Column Chart

Data on electric field emissions from 26 irons were gathered. A bar chart and a column chart were used to display the data on the graph. The lowest electric field emissions measured in this instance are 0.5 V/m.We can observe the emissions' fluctuation. The majority of magnetic field outputs ranged from 0.5 to 9.5 V/m.The measurement of the greatest electric field emissions is 48.66 V/m.

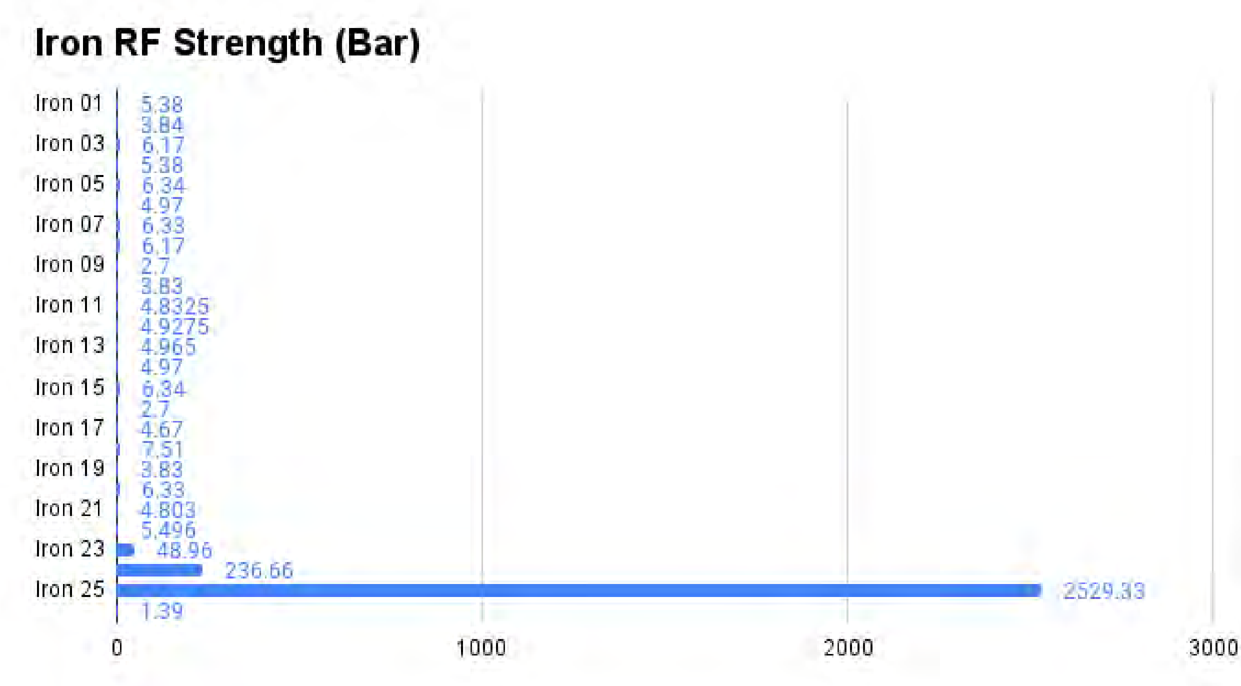

Figure 122: Iron RF Strength (µW/m²) Bar Chart

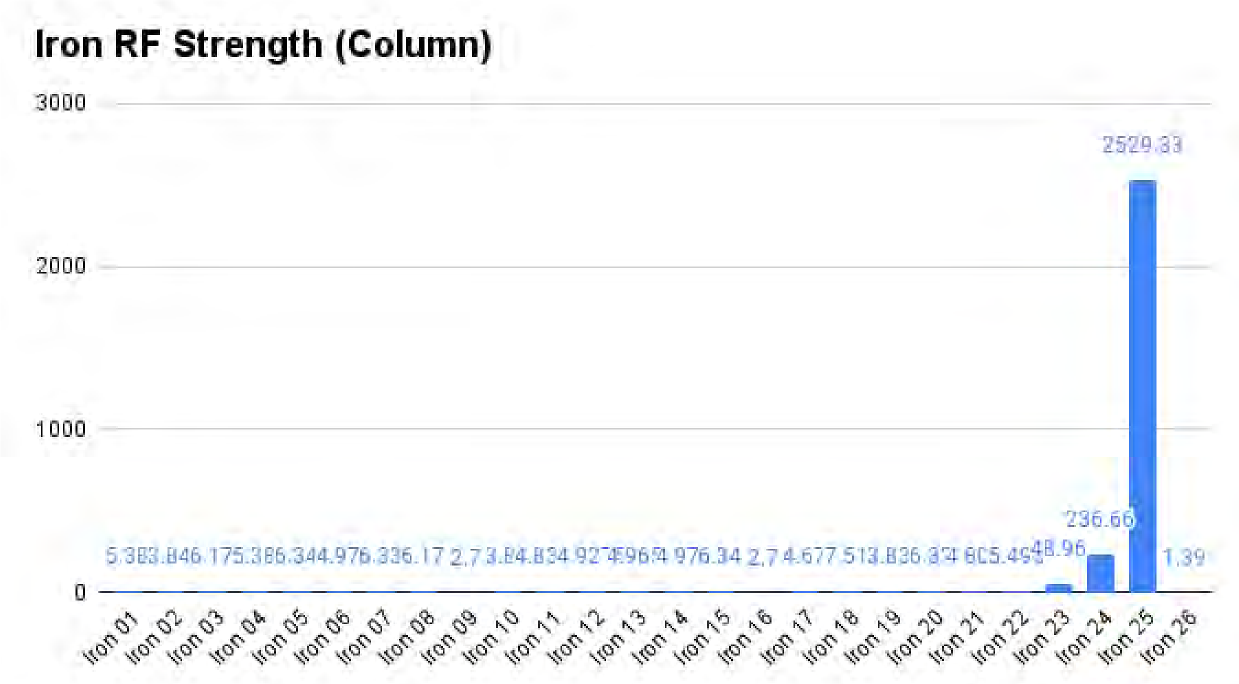

Figure 123: Iron RF Strength (µW/m²) Column Chart

We gathered information on the RF strength emissions from 26 irons. A bar chart and a column chart were used to display the data on the graph. The lowest RF strength emissions measured here are 1.39 µW/m². We can observe the emissions' fluctuation. The range of RF strength emissions was 1.39 to 49 for the most part. The measurement for the highest RF strength emissions is 2529.33 µW/m².

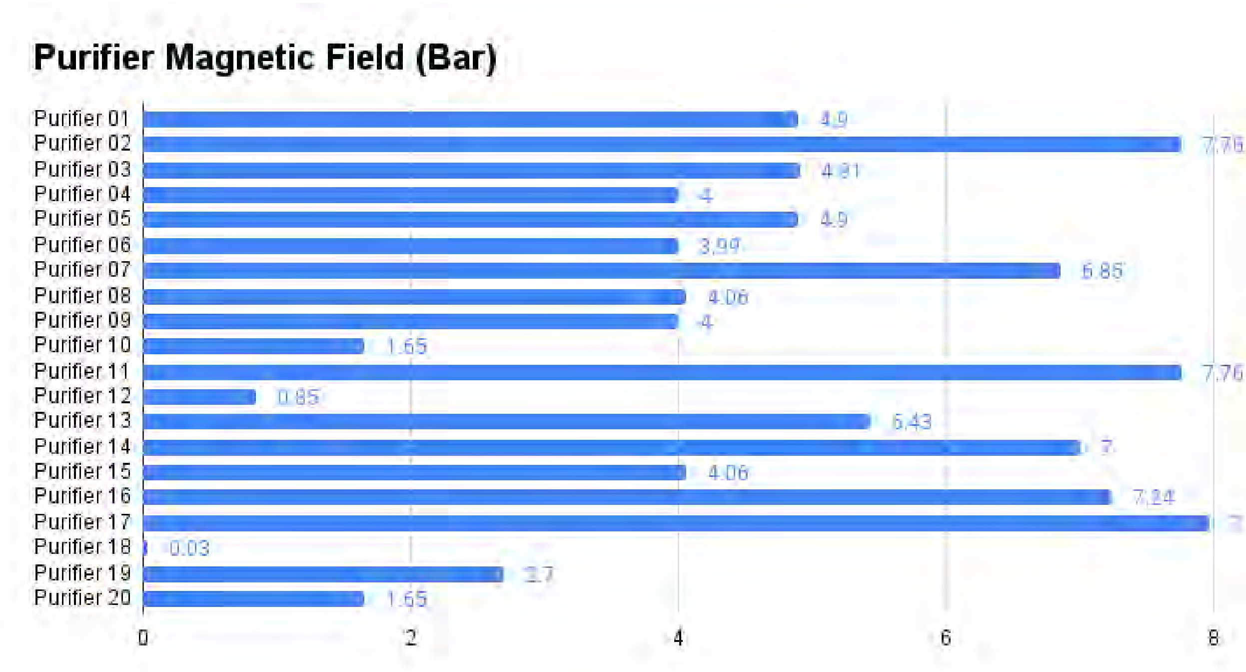

Figure 124: Purifier Magnetic Field (mG) Bar Chart

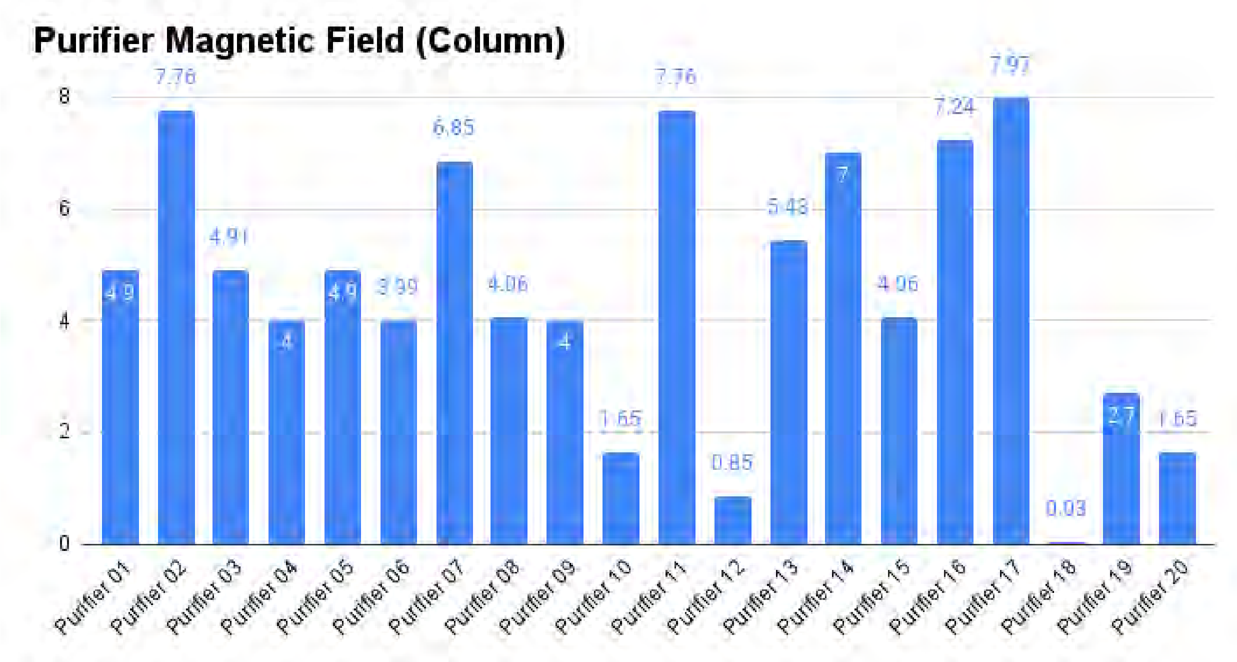

Figure 125 : Purifier Magnetic Field (mG) Column Chart

From 20 purifiers, we gathered data on magnetic field emissions. A bar chart and a column chart were used to display the data on the graph. The lowest observed magnetic field emissions in this instance are 0.03 mG. We can observe the emissions' fluctuation. The majority of magnetic field outputs were less than 8 mG. The strongest magnetic field emissions, 7.97 mG, are detected.

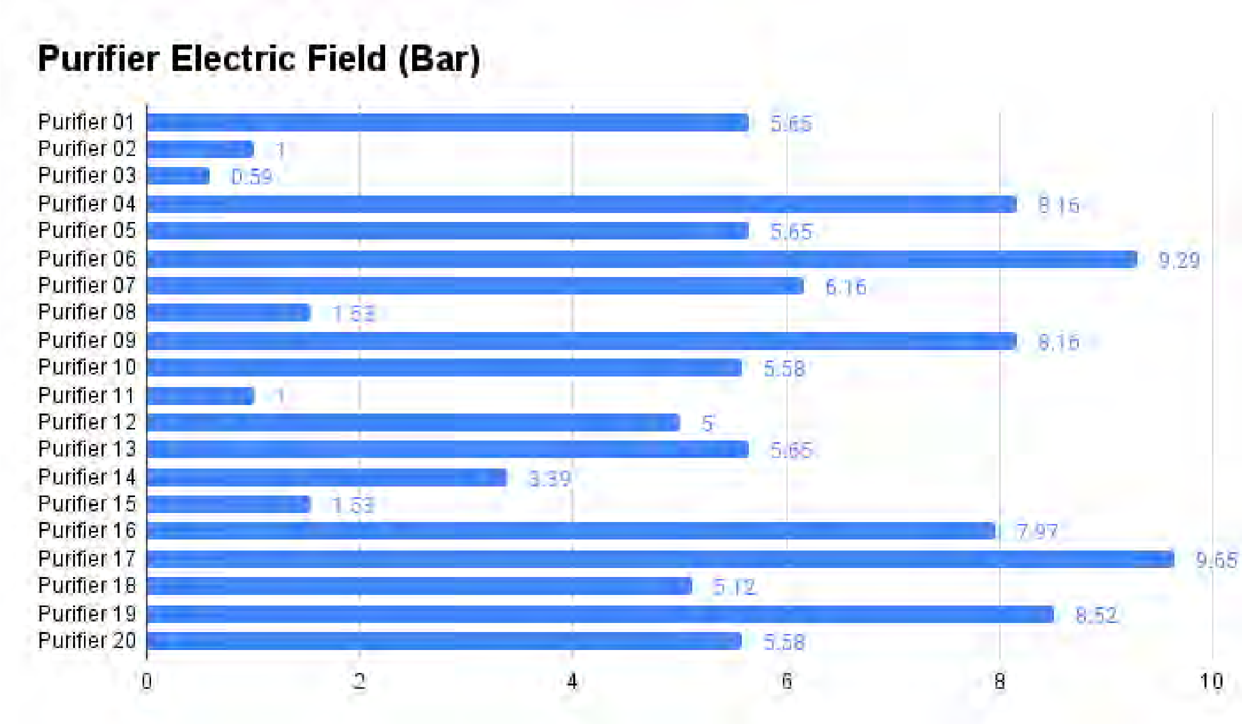

Figure 126: Purifier Electric Field (V/m) Bar Chart

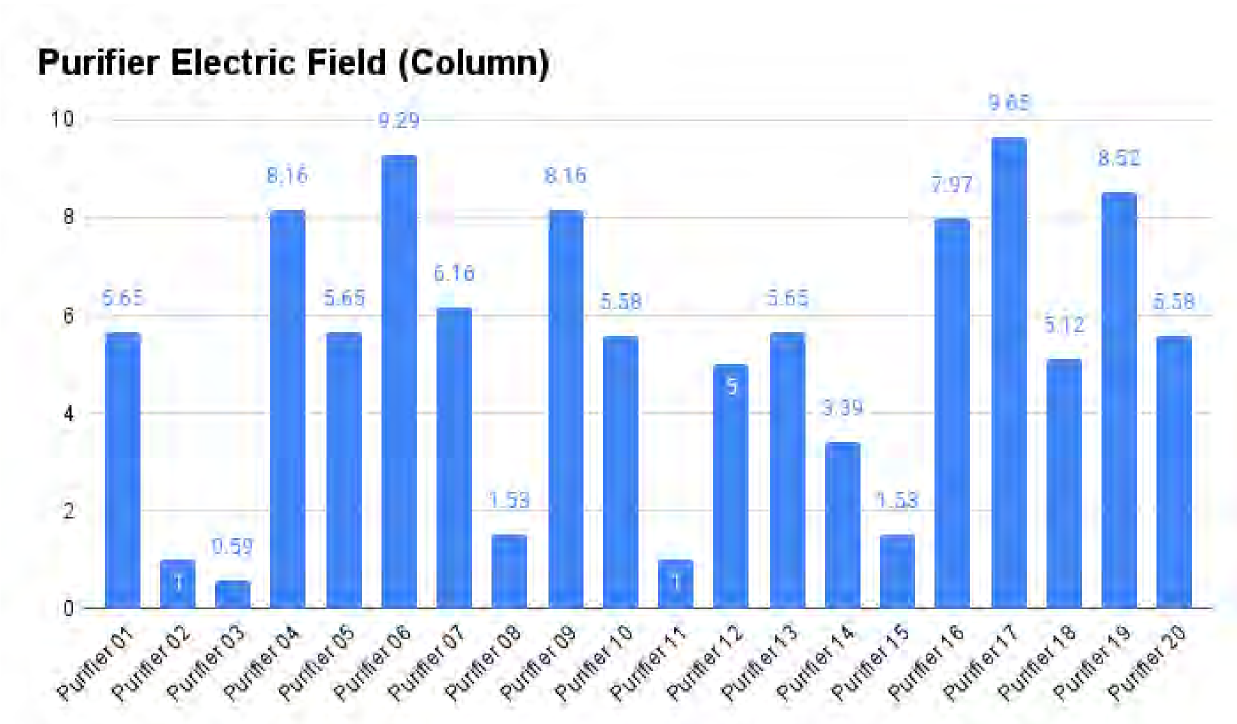

Figure 127: Purifier Electric Field (V/m) Column Chart

We gathered electric field emission data from 20 purifiers. A bar chart and a column chart were used to display the data on the graph. The lowest observed electric field emissions in this instance are 1 V/m. We can observe the emissions' fluctuation. The majority of electric field emissions were less than 10 V/m.The electric field emissions with the maximum measurement are 9.65 V/m.

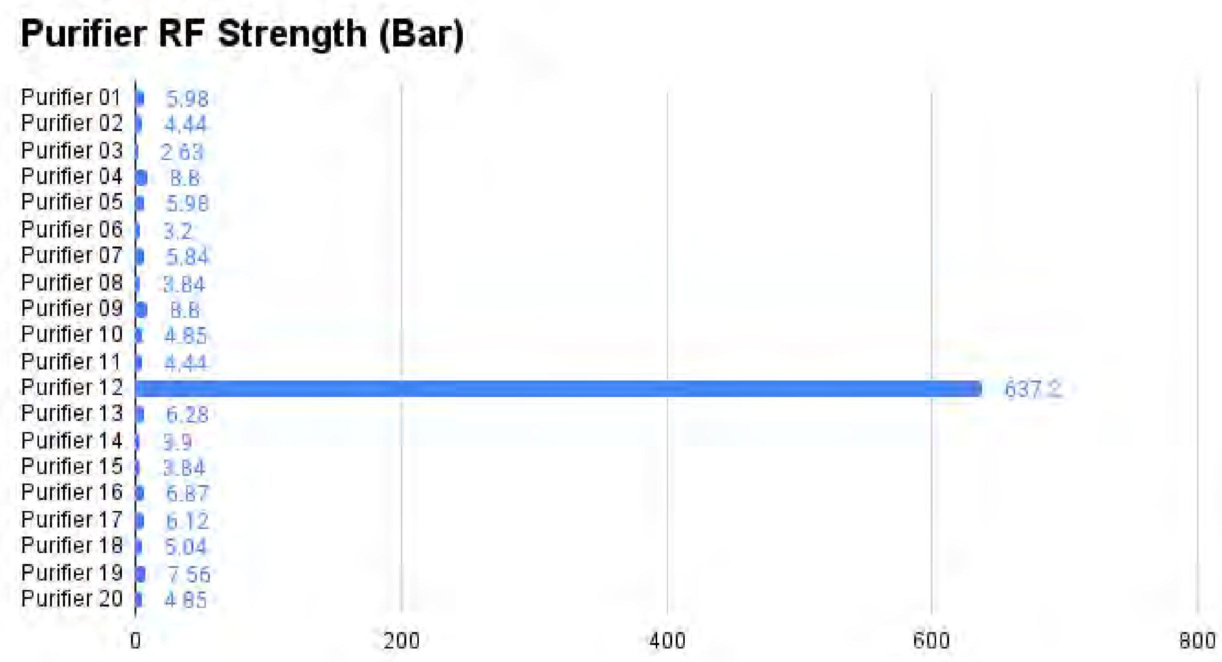

Figure 128: Purifier RF Strength (µW/m²) Bar Chart

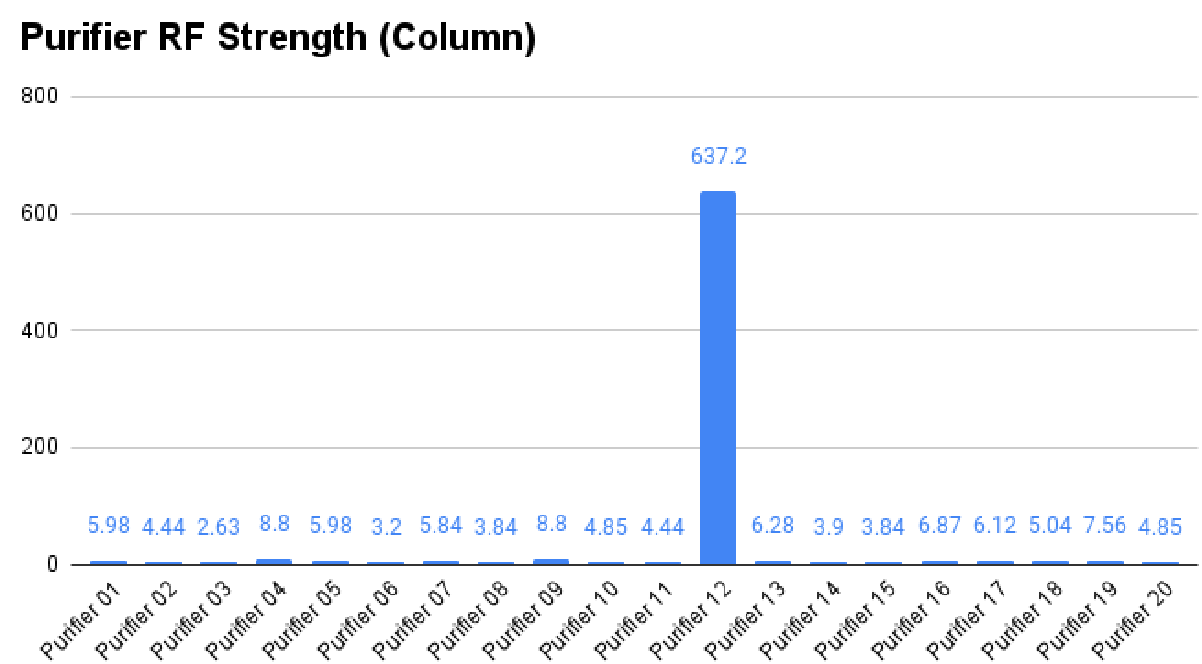

Figure 129: Purifier RF Strength (µW/m²) Column Chart

We gathered information on the RF strength outputs from 20 purifiers. A bar chart and a column chart were used to display the data on the graph. The lowest reported RF strength emissions in this instance are 2.6 µW/m². We can observe the emissions' fluctuation. The majority of the RF strength emissions were less than 9 µW/m². The measurement of the greatest RF strength emissions is 637.2 µW/m².

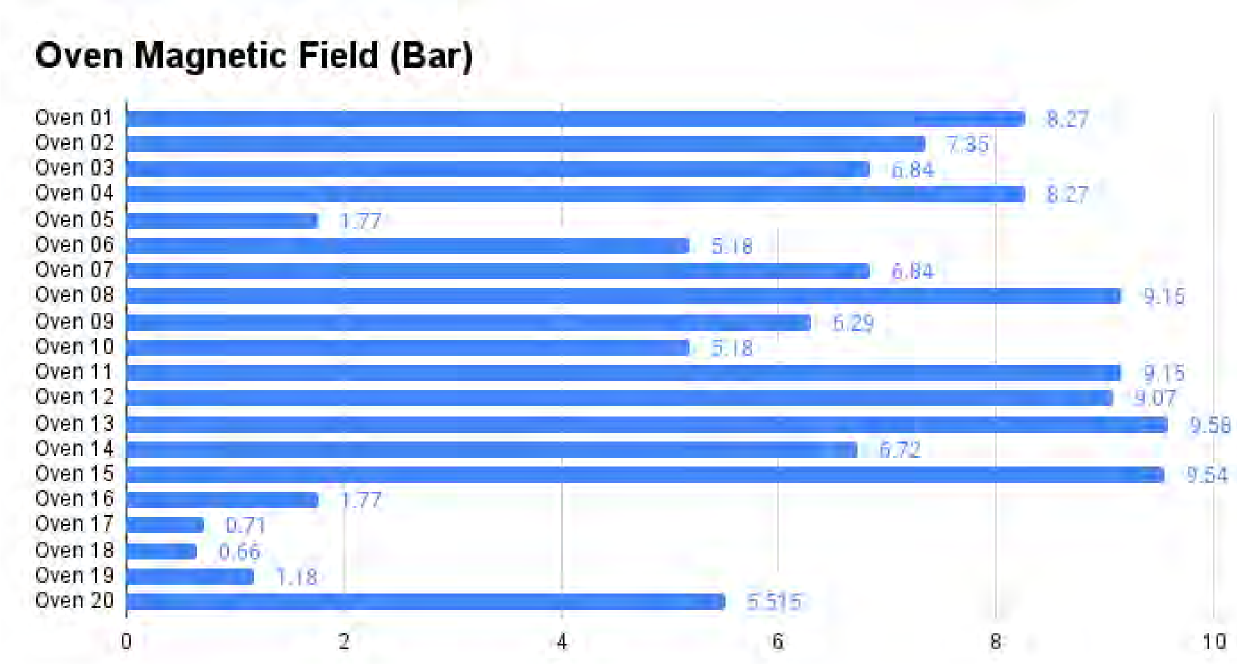

Figure 130: Oven Magnetic Field (mG) Bar Chart

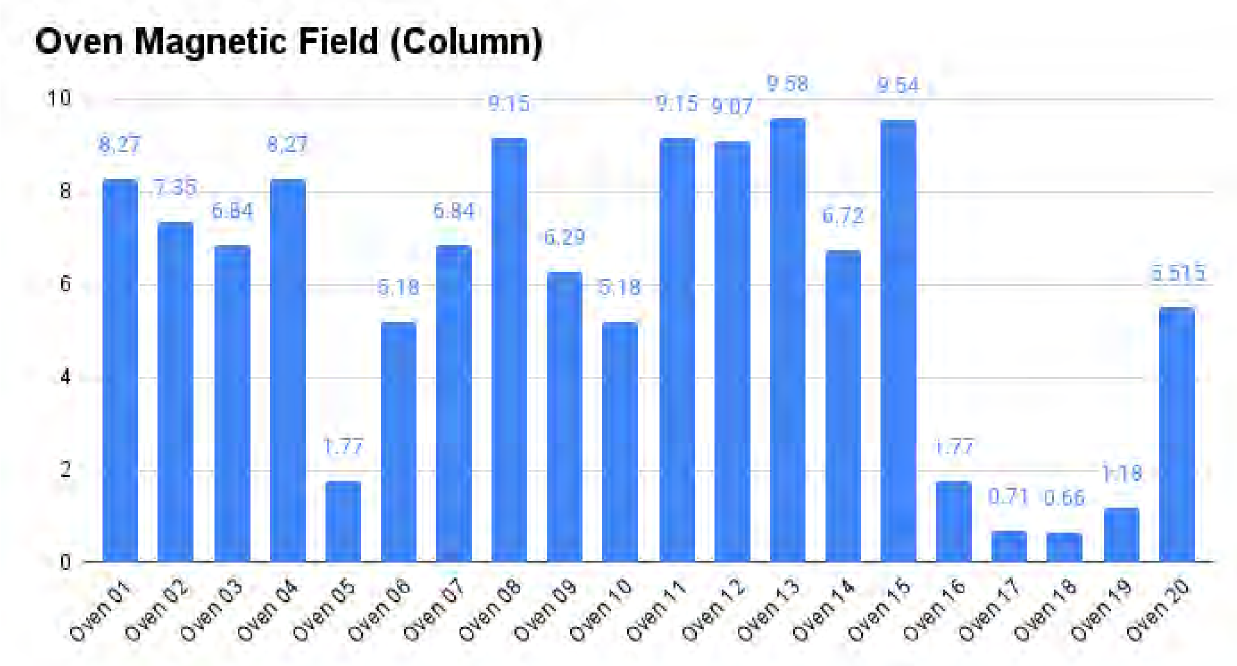

Figure 131: Oven Magnetic Field (mG) Column Chart

Data about magnetic field emissions was gathered from 20 Oven. Both a bar chart and a column chart were used to display the data. The lowest reported magnetic field outputs in this instance are 0.66 mG. The emissions' fluctuation is visible to us. Below 10 mG, the majority of magnetic field emissions were detected. The strongest magnetic field emissions, 9.58 mG, are detected.

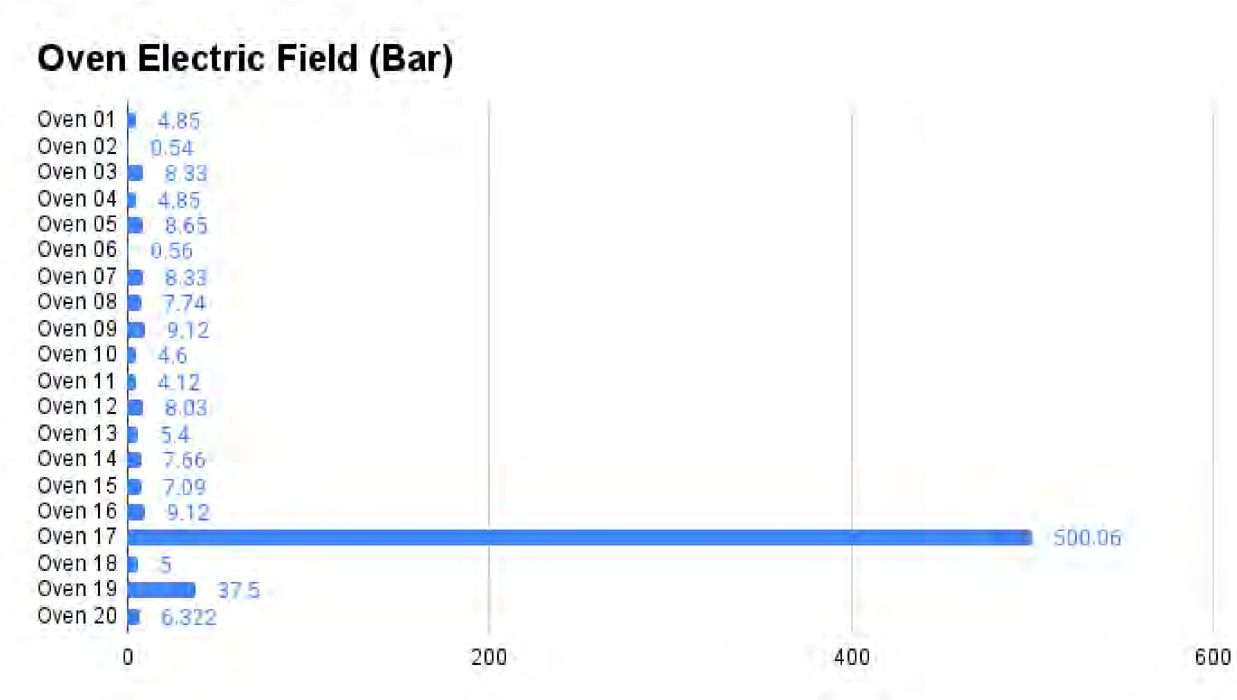

Figure 132: Oven Electric Field (V/m) Bar Chart

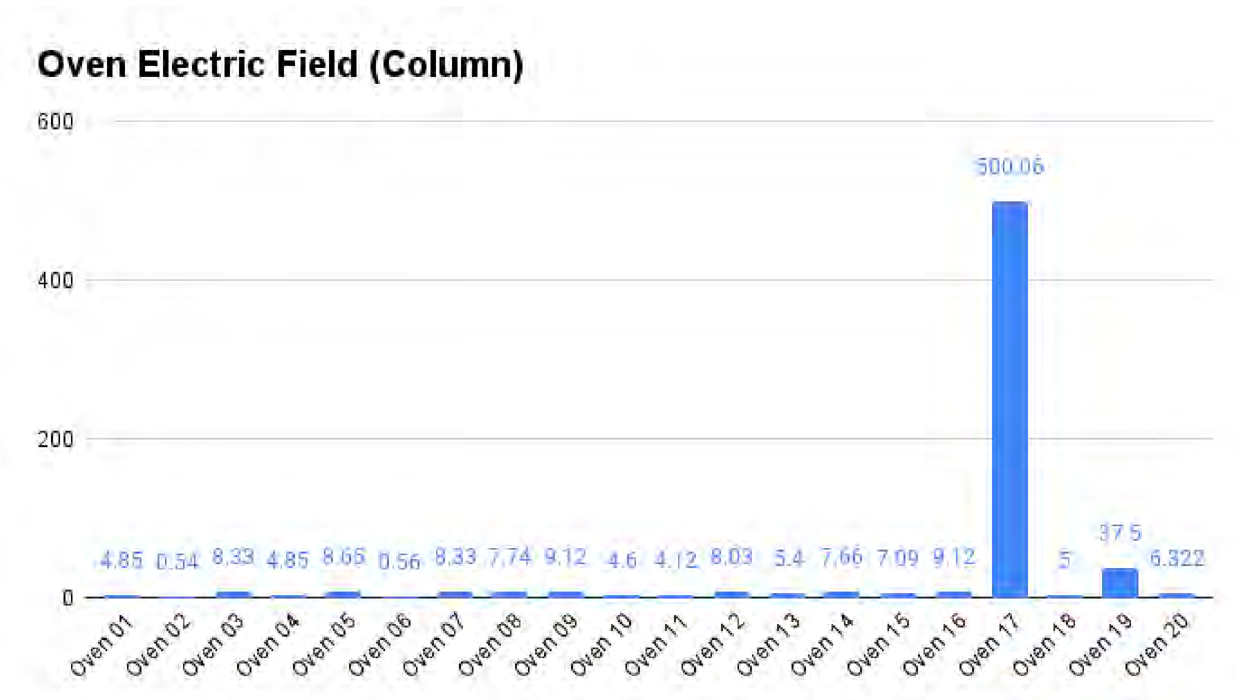

Figure 133: Oven Electric Field (V/m) Column Chart

We gathered information from 20 Oven on electric field emissions. A bar chart and a column chart were used to display the data on the graph. The lowest electric field emissions measured in this instance are 0.54 V/m.We can observe the emissions' fluctuation. Emissions from electric fields were mostly below 38 V/m.The electric field emissions with the maximum value are 500.06 V/m.

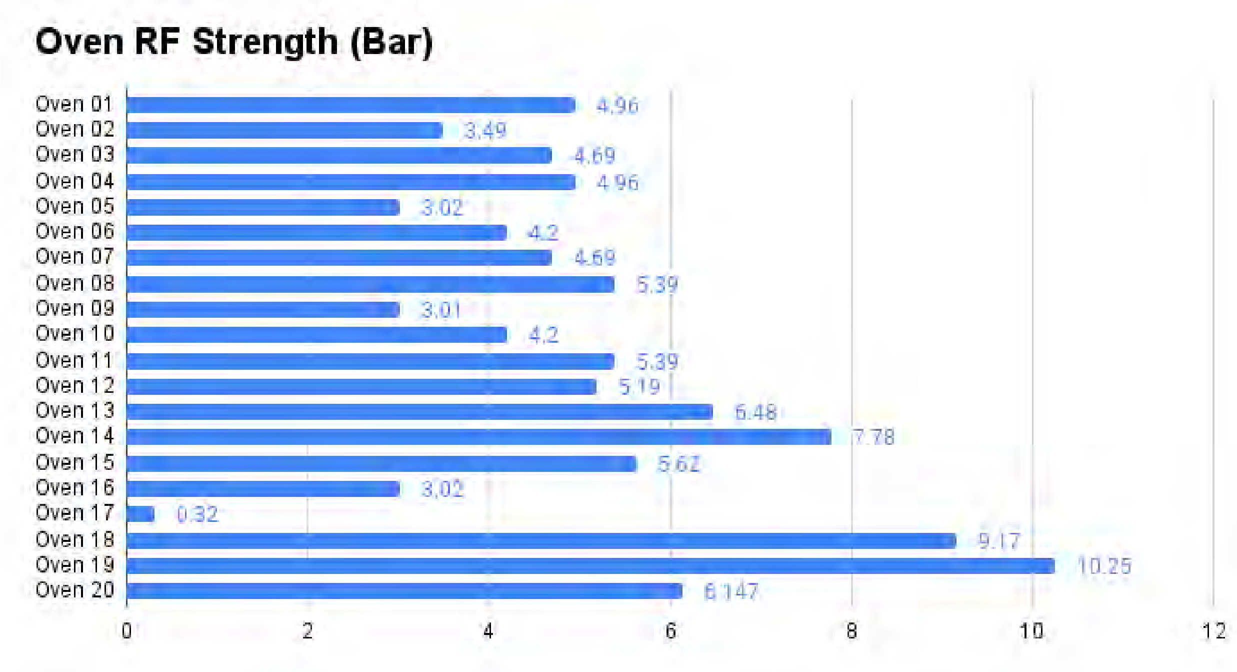

Figure 134: Oven RF Strength (µW/m²) Bar Chart

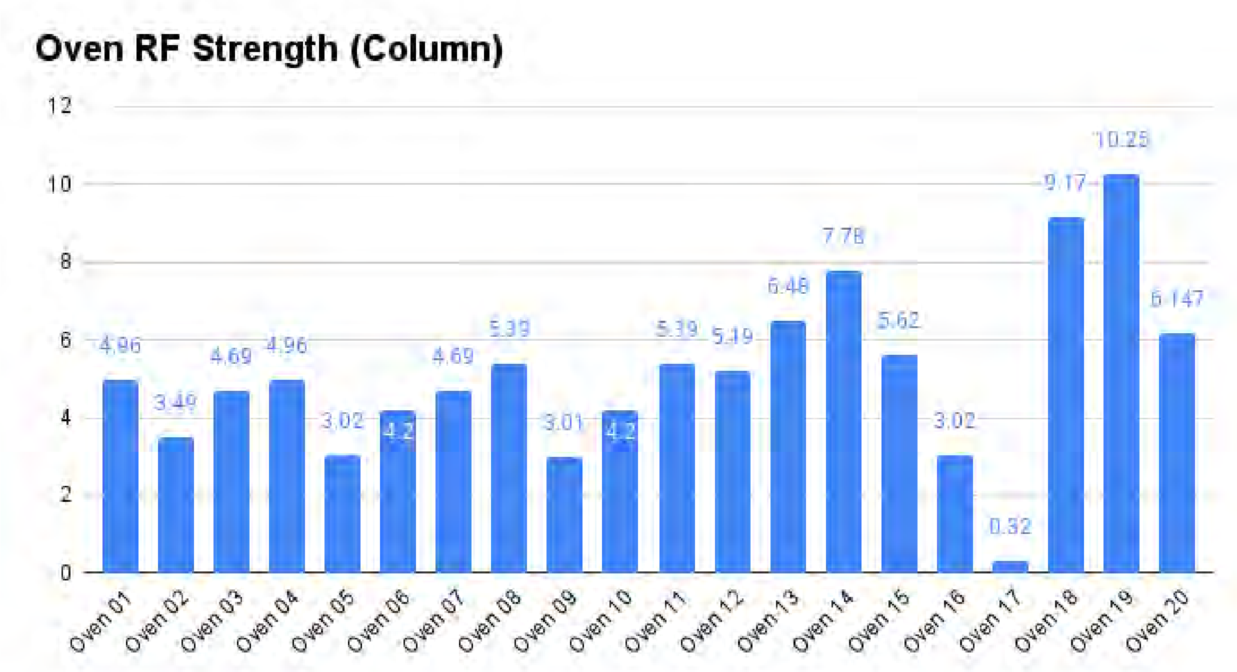

Figure 135: Oven RF Strength (µW/m²) Column Chart

From 20 Oven, we gathered data about RF strength emissions. Both a bar chart and a column chart were used to display the data. In this case, the lowest reported RF strength emissions are 0.32 µW/m². The emissions' fluctuation is visible to us. Emissions of RF intensity were mostly below 11 µW/m². The measurement for the greatest RF strength emissions is 10.25 µW/m².

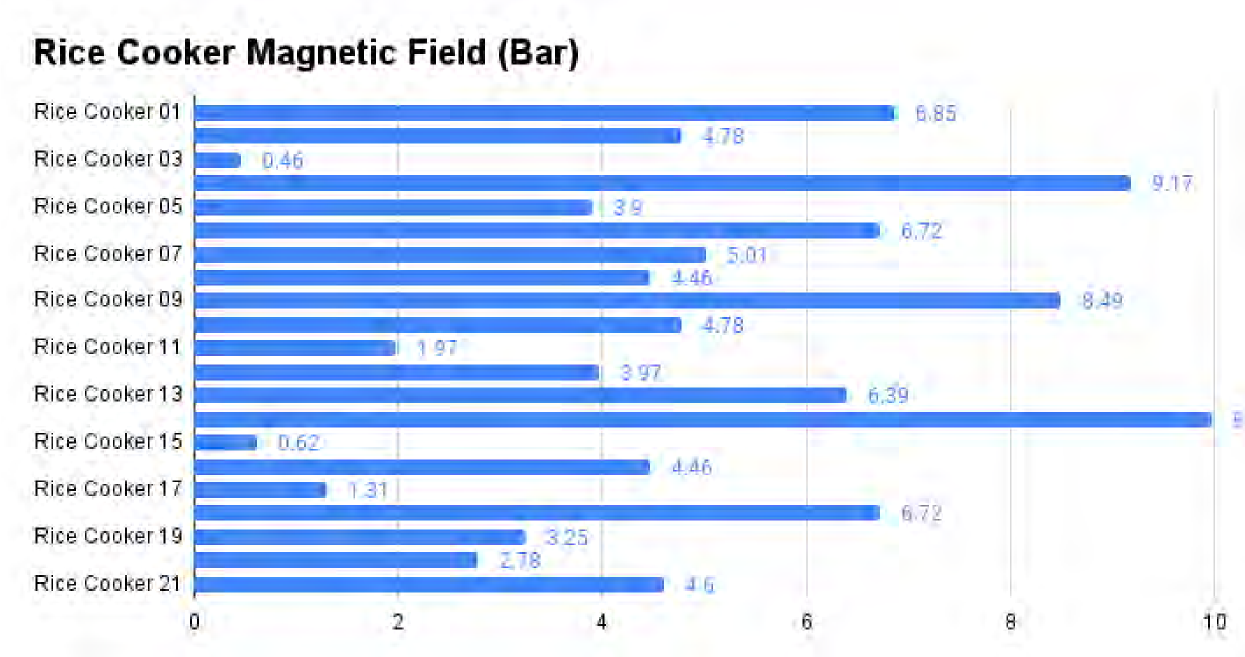

Figure 136: Rice Cooker Magnetic Field (mG) Bar Chart

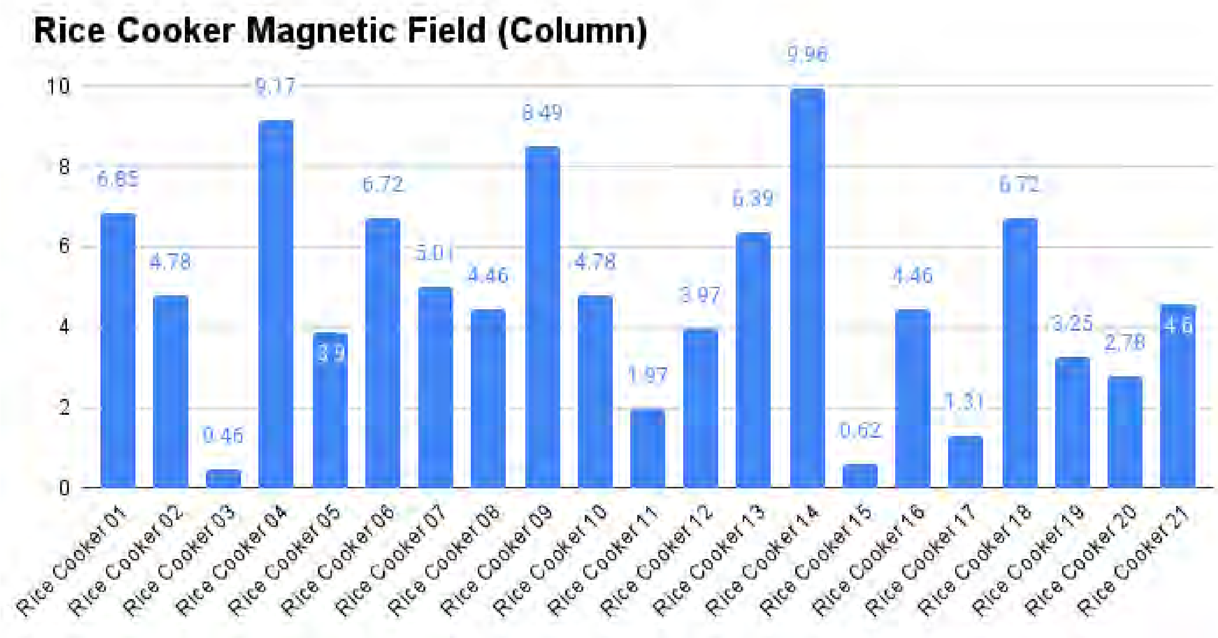

Figure 137: Rice Cooker Electric Field (V/m) Column Chart

For magnetic field emissions, we gathered information from 21 rice cookers. Both a bar chart and a column chart were used to display the data. In this case, 0.46 mG is the lowest magnetic field emissions observed. The emissions' fluctuation is visible to us. Magnetic field emissions were mostly below 10 mG. The strongest magnetic field emissions, 9.96 mG, are detected.

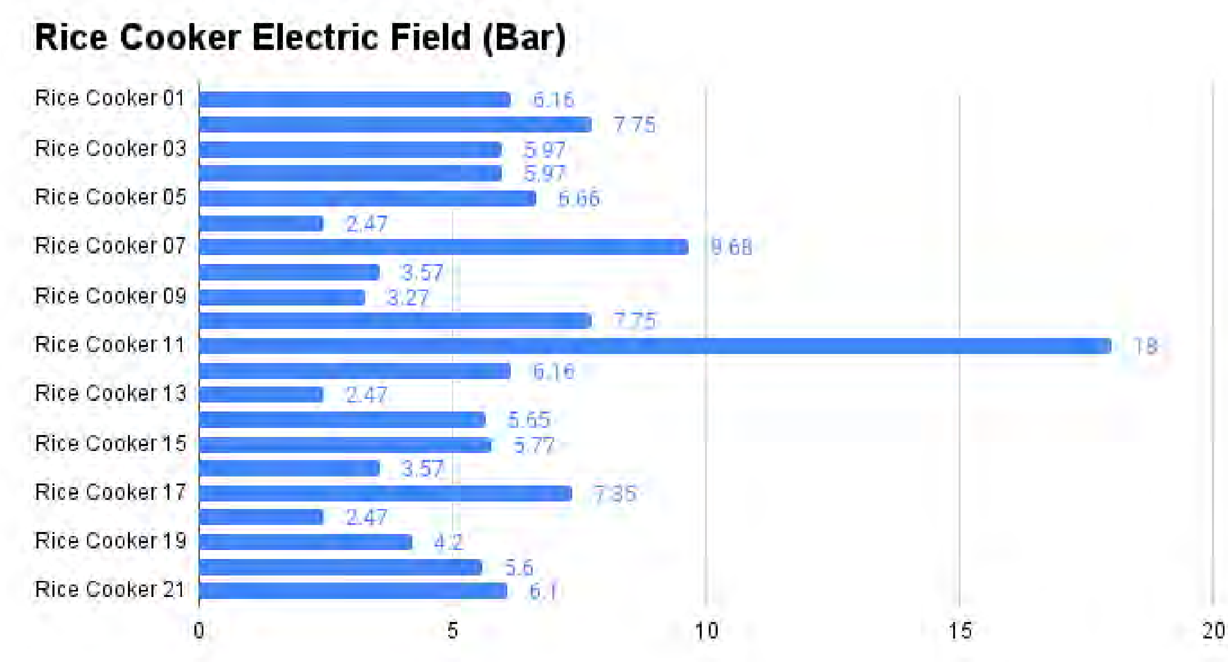

Figure 138: Rice Cooker Electric Field (V/m) Bar Chart

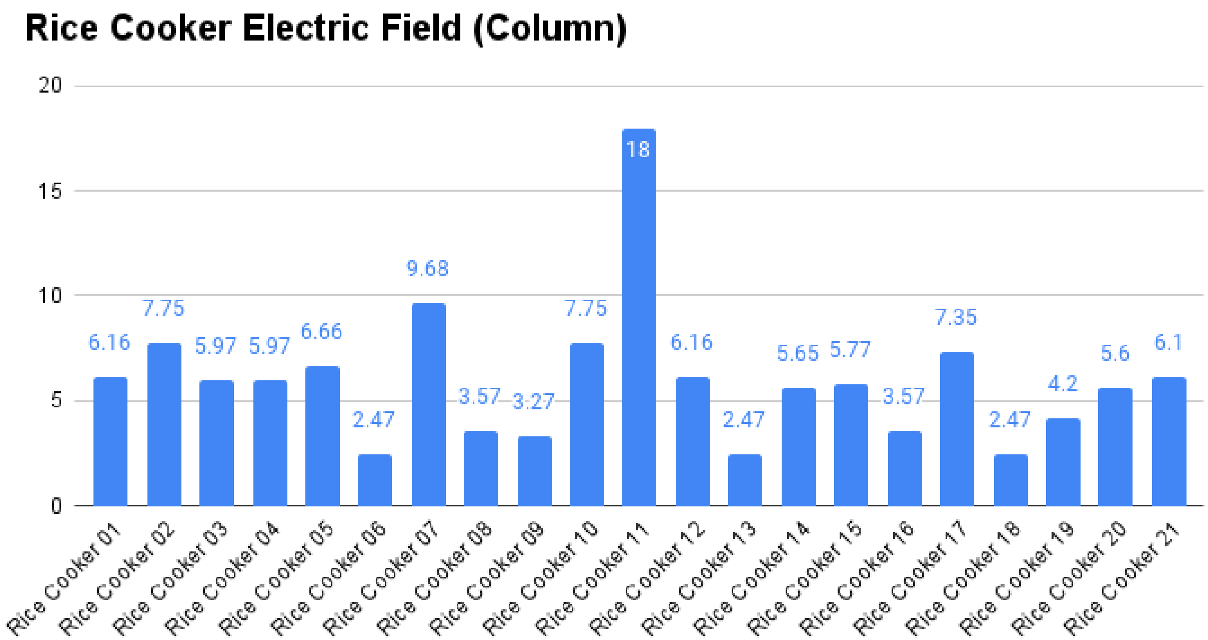

Figure 139: Rice Cooker Electric Field (V/m) Column Chart

From 21 rice cookers, we gathered data on electric field emissions. The graph displayed the data as a column chart and a bar chart. 2.47 V/m is the lowest electric field emissions measured here.The emission fluctuation is visible. Emissions of electric fields ranged from 2 V/m to 10 V/m. There is only one electric field emission, measured at 18 V/m, that is higher than the others.

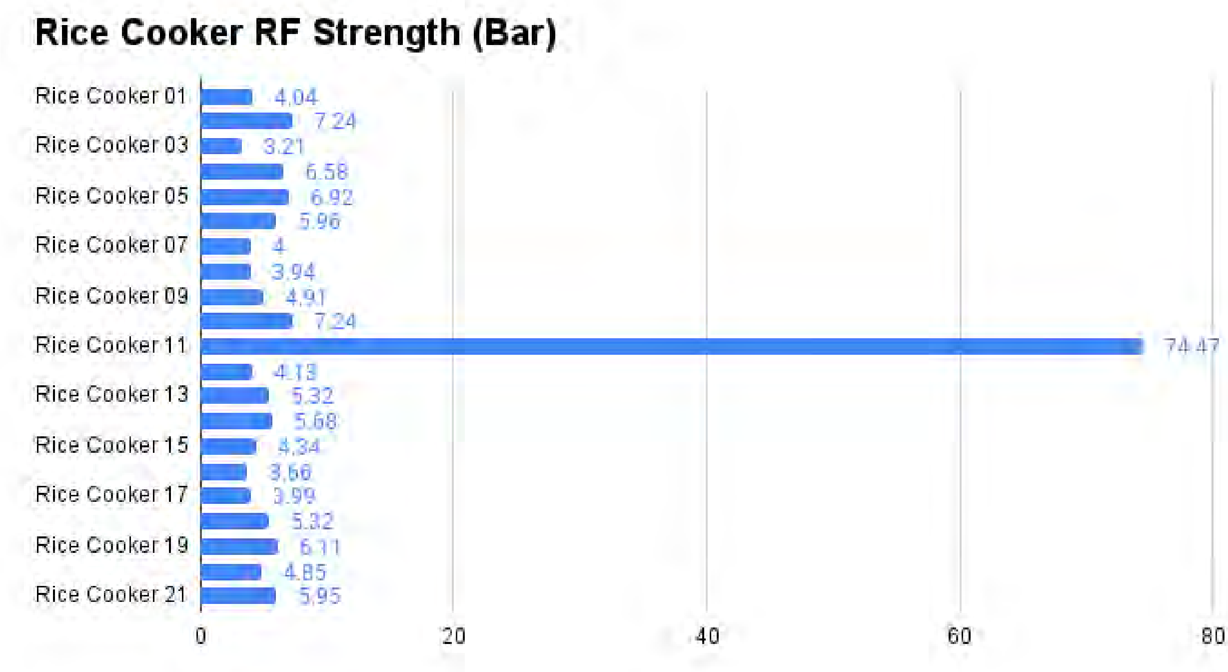

Figure 140: Rice Cooker RF Strength (µW/m²) Bar Chart

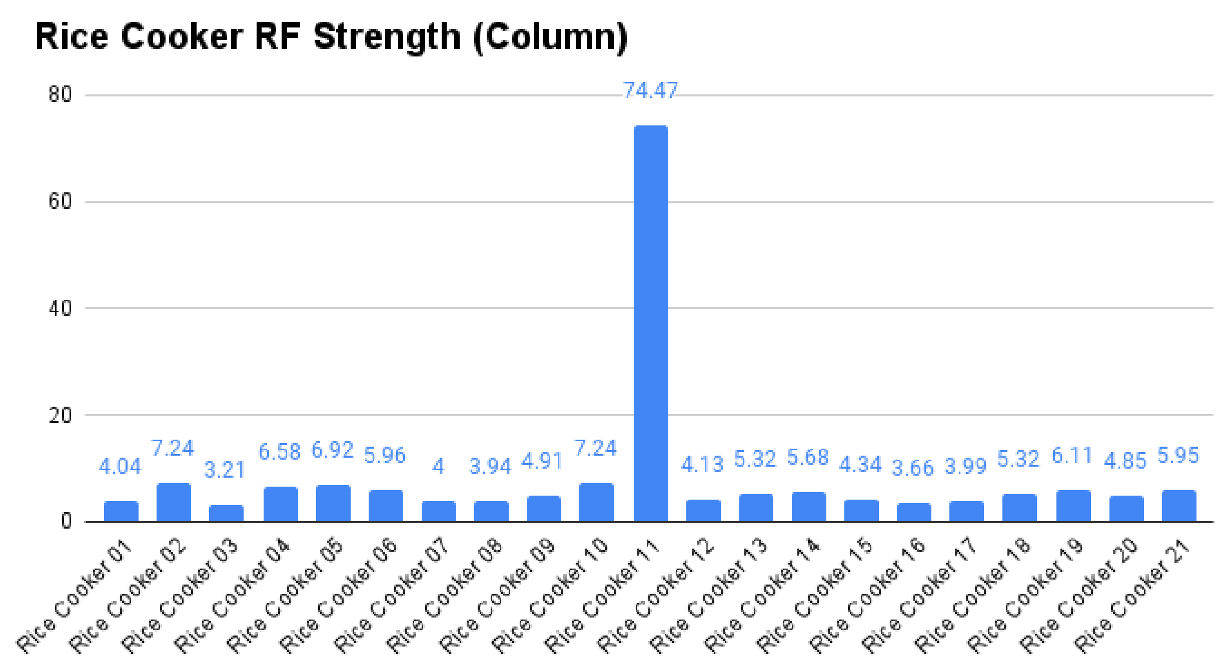

Figure 141: Rice Cooker RF Strength (µW/m²) Column Chart

We gathered information on 21 rice cookers' RF strength emissions.The graph displayed the data as a column chart and a bar chart. Here, 3.21 µW/m² is the lowest reported RF strength emissions.The emission fluctuation is visible. The majority of RF strength emissions ranged from

3 to 7.5 µW/m².Only one RF strength emission, measured at 74.47 µW/m², is greater than the others.

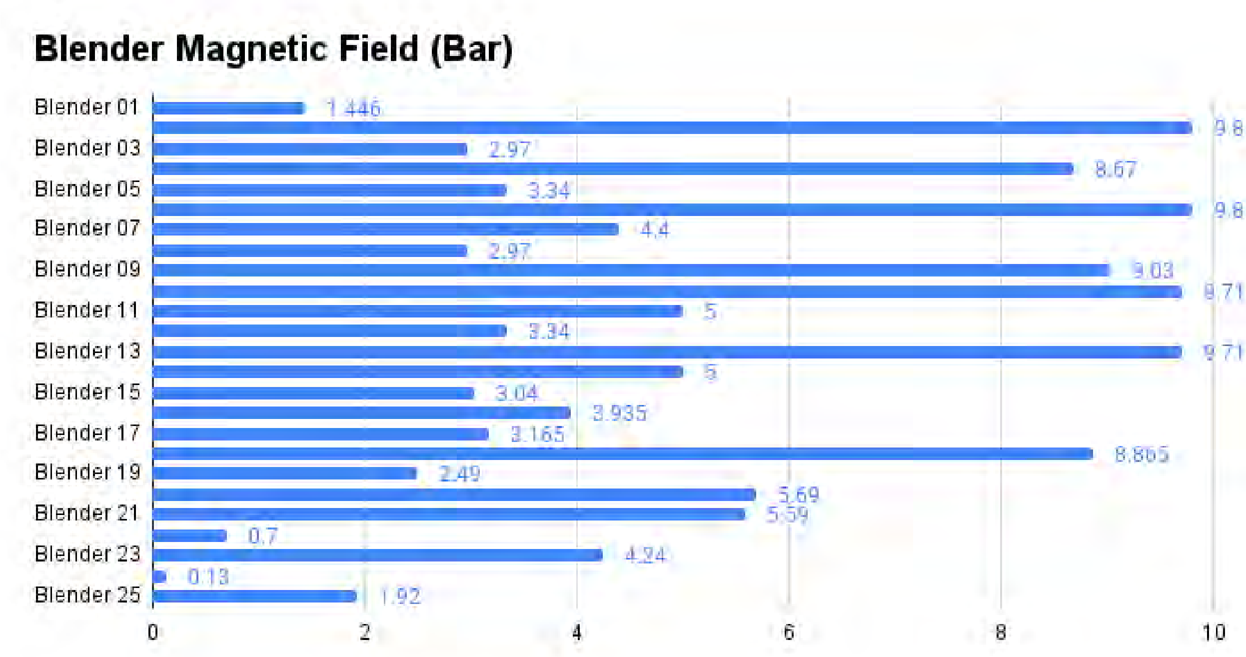

Figure 142: Blender Magnetic Field (mG) Bar Chart

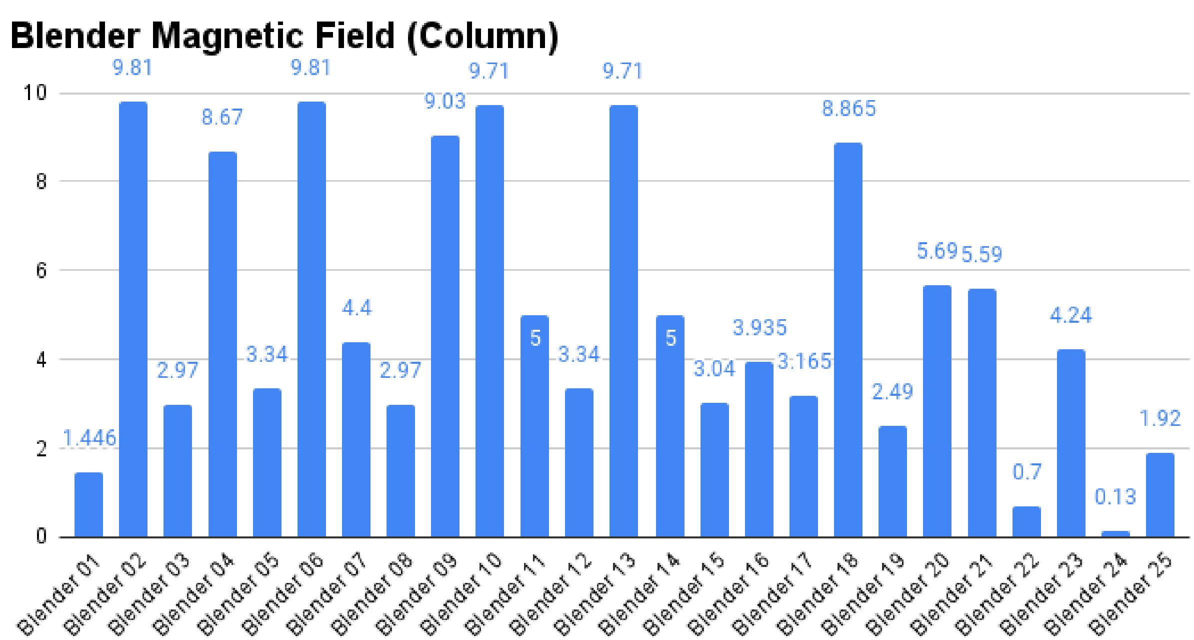

Figure 143: Blender Magnetic Field (mG) Column Chart

We gathered data from 25 Blender on magnetic field emissions. Both a bar chart and a column chart were used to display the data. The lowest observed magnetic field outputs in this instance are 0.13 mG. The emissions' fluctuation is visible to us. The majority of magnetic field emissions were below 10 mG. The maximum observed magnetic field emissions were 9.81 mG.

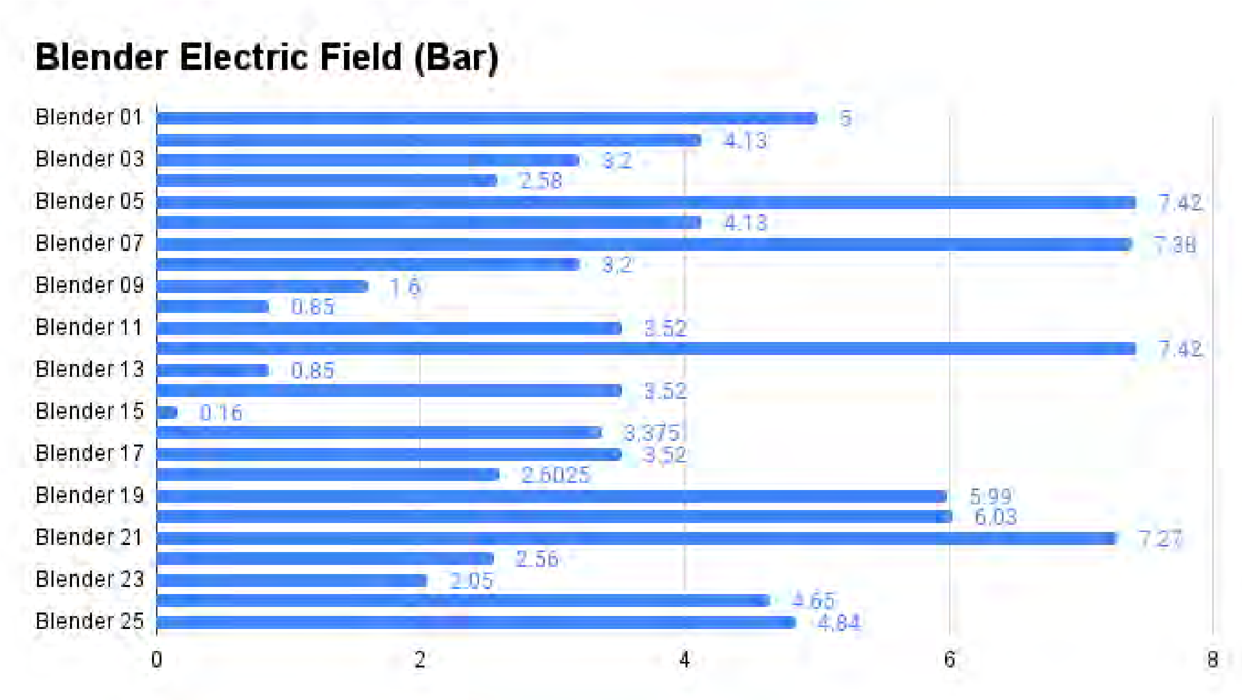

Figure 144: Blender Electric Field (V/m) Bar Chart

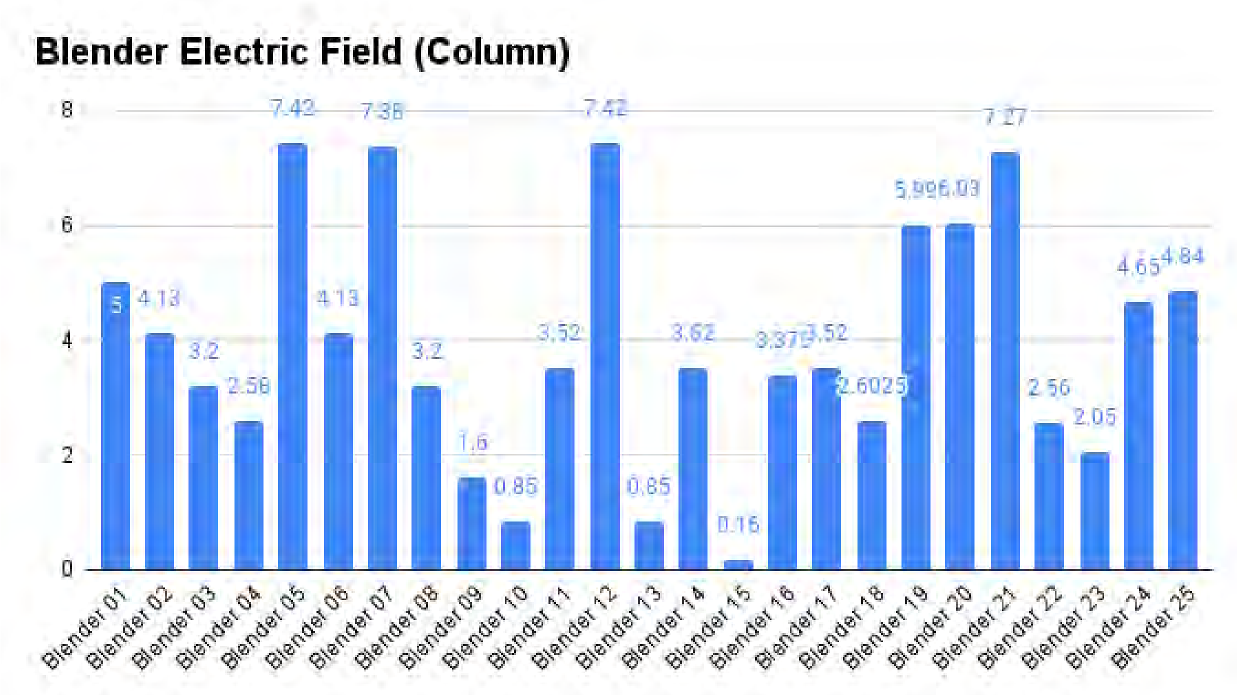

Figure 145: Blender Electric Field (V/m) Column Chart

Data on electric field emissions was gathered from 25 Blenders.A bar chart and a column chart were used to display the data on the graph. The lowest observed electric field emissions in this instance are 0.16 V/m.We can observe the emissions' fluctuation. The majority of electric field emissions were less than 8 V/m. The maximum observed electric field emissions were 7.42 V/m.

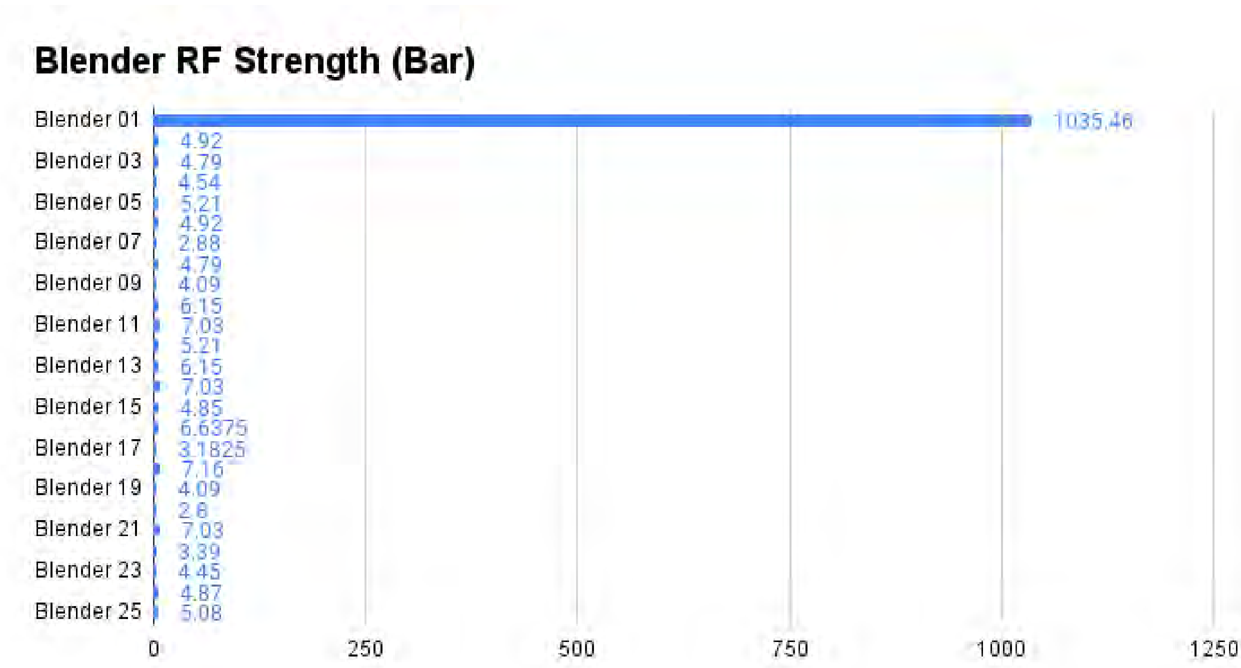

Figure 146: Blender RF Strength (µW/m²) Bar Chart

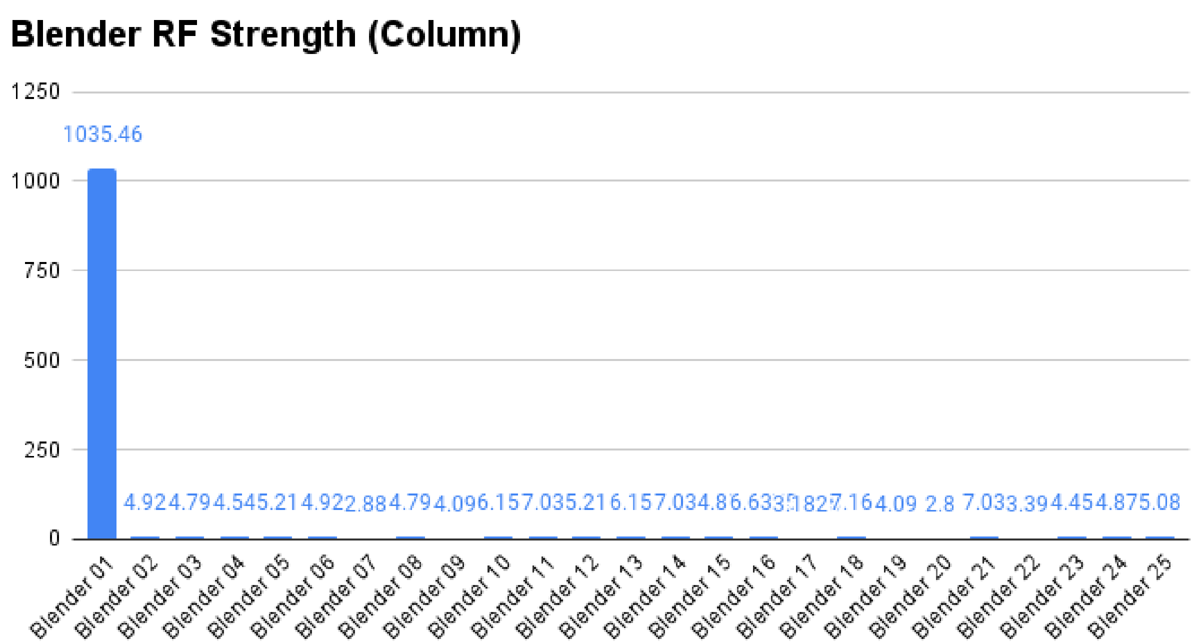

Figure 147: Blender RF Strength (µW/m²) Column Chart

From 25 Blender, we gathered information about RF strength emissions. The graph displayed the data as a column chart and a bar chart. In this case, 2.8 µW/m² is the lowest electric field emissions measured. The emission fluctuation is visible. The majority of the emissions of RF strength were below 8 $\mu W/m^2$. Only one RF strength emission was observed as higher than the usual emission, which was 1035.46 $\mu W/m^2$.

Chapter 9

Discussion

In the ever-evolving landscape of technology, the safety of household appliances concerning non-ionizing radiation (NIR) emissions has become a pressing concern. As appliances become increasingly integral to our daily lives, understanding the emissions they generate is critical for ensuring user safety. This discussion delves into the findings of our study, highlighting key aspects of the results, statistical analyses, and graphical representations while exploring variations across different appliances.

Statistical Analysis

The statistical analysis conducted in this study primarily revolved around hypothesis testing, employing a one-sample t-test to assess the NIR emissions from various household appliances. The null hypothesis (H_0) proposed that the NIR emissions from these appliances do not significantly exceed established safety limits for magnetic fields, electric fields, and radio frequency emissions. Conversely, the alternative hypothesis (H_1) posited that these emissions do indeed surpass the recommended safety thresholds.

The findings revealed a spectrum of emissions across different appliances. For instance, in terms of magnetic field strengths, while cell phones exhibited an average of 2.47 mG well within safe exposure limits the electric field emissions from switches, averaging 51.22 V/m, raised significant concerns due to their stark breach of the safety threshold. In stark contrast, televisions and refrigerators showed a commendable alignment with safety standards, showcasing average magnetic field strengths within acceptable ranges.

The statistical analysis not only illuminated compliance but also exposed alarming deviations. The RF strength from laptops and some appliances, such as the washing machine, was found to be alarmingly high, with readings of 1879.78 μW/m² and 2105.17 μW/m², respectively, significantly exceeding the safety limits. Such findings necessitate urgent attention as they highlight potential health risks associated with prolonged exposure to elevated levels of non-ionizing radiation.

Moreover, the statistical significance of these findings underscores the importance of continuous monitoring and regulation of emissions from household appliances. With the growing reliance on technology, the need for stringent safety standards becomes paramount to safeguard public health.

Graphical Analysis

The graphical analysis serves as a visual representation of the collected data, enhancing comprehension of the varied emissions across different appliance categories. Utilizing bar and column charts, the analysis effectively illustrates the fluctuations in magnetic field, electric field, and RF strength emissions from the tested appliances.

For instance, the magnetic field emissions from cell phones were graphically depicted, revealing that while the average emission was a safe 2.47 mG, two devices approached the upper safety threshold of 9.31 mG, highlighting a critical area for consumer awareness. In comparison, televisions exhibited a mean magnetic field strength of 2.41 mG comfortably within the safety range of 0.1 to 10 mG demonstrating a notable difference in safety compliance.

The electric field emissions from switches stood out dramatically, with an average of 51.22 V/m, far exceeding the safety limit of 1-20 V/m. Comparatively, the average electric field emissions from televisions were a mere 20.61 V/m, indicating compliance within the safe limits. This stark contrast emphasizes the need for scrutiny of certain appliance categories.

When examining RF strength emissions, laptops emerged as a significant outlier, averaging 1879.78 $\mu W/m^2$, which is alarmingly above the safety threshold of 450 $\mu W/m^2$. In contrast, refrigerators maintained a safe RF strength average of 68.25 $\mu W/m^2$, clearly illustrating the disparity in emissions among different appliance types.

The graphical representation of these emissions vividly illustrates the disparities, allowing for an intuitive understanding of where potential risks lie. For instance, while most appliances like microwaves and rice cookers exhibited safe RF emissions of 5.09 µW/m² and 8.46 µW/m², the alarming readings from the laptop and washing machine highlighted the variability across categories.

Furthermore, the analysis of appliances like washing machines and refrigerators showcased the variability in emissions. While some appliances, such as the microwave oven and refrigerator consistently demonstrated compliance with safety standards, others, particularly the laptop and switch, exhibited concerning levels of emissions, underscoring the need for further investigation and potential regulatory action.

This variational analysis reveals critical insights. For example, while most kitchen appliances like rice cookers (mean RF strength of 8.46 µW/m²) and blenders (mean RF strength of 45.38 µW/m²) adhered to safety standards, devices like the switch (RF strength of 628.92 µW/m²) and laptop (RF strength of 1879.78 µW/m²) necessitate immediate attention.

Moreover, the graphical representation of these variations enables stakeholders, including policymakers, manufacturers, and consumers, to make informed decisions. By identifying which appliances pose greater risks, appropriate measures can be implemented to enhance safety, such as improved shielding, better design practices, or consumer education on safe usage.

Radiation Awareness

Understanding Non-Ionizing Radiation Emissions from Household Appliances

In our modern world, household appliances play a vital role in enhancing convenience and efficiency in daily life. However, as we integrate more technology into our homes, the potential health impacts of non-ionizing radiation (NIR) emissions have garnered increasing attention. This awareness is crucial for consumers, manufacturers, and regulators alike, as it can directly affect public health and safety.

Understanding Non-Ionizing Radiation

Non-ionizing radiation refers to electromagnetic radiation that does not carry enough energy to ionize atoms or molecules. It includes a broad spectrum of radiation types, such as radio waves, microwaves, and lower-frequency electromagnetic fields, all of which are emitted by common household devices. While NIR is generally perceived as less harmful than ionizing radiation (such as X-rays or gamma rays), it is essential to understand that prolonged exposure to high levels of NIR can still pose health risks.

Sources of Non-Ionizing Radiation in the Home

Numerous household appliances emit NIR. Key sources include:

1. **Cell Phones**: These devices emit radiofrequency (RF) radiation during use, which has raised concerns about potential long-term health effects.
2. **Microwave Ovens**: While designed to contain radiation, malfunctioning units can leak RF emissions.
3. **Televisions**: Modern flat-screen TVs emit low levels of electromagnetic fields (EMF) but are generally considered safe.
4. **Computers and Laptops**: These devices generate both electric and magnetic fields, especially when in use for extended periods.
5. **Kitchen Appliances**: Blenders, rice cookers, and other appliances also emit various levels of NIR.

Understanding where these emissions originate is the first step in mitigating potential risks.

Health Implications of Non-Ionizing Radiation

The health effects of NIR exposure remain a subject of ongoing research and debate. While some studies have suggested links between high levels of exposure to non-ionizing radiation and adverse health effects, definitive conclusions have yet to be established.

1. **Thermal Effects**: One of the most widely acknowledged concerns is thermal exposure, where excessive heat generated by RF emissions can affect biological tissues. This is particularly relevant for devices that operate at high frequencies, like microwave ovens.

2. **Potential Long-Term Effects**: Some epidemiological studies have explored the potential long-term effects of NIR exposure, particularly from cell phones. Concerns have been raised about an increased risk of brain tumors, but results remain inconclusive.

3. **Electromagnetic Hypersensitivity (EHS)**: A subset of individuals reports adverse symptoms when exposed to electromagnetic fields, a condition often referred to as electromagnetic hypersensitivity. Symptoms can include headaches, fatigue, and cognitive difficulties. However, scientific validation of EHS is limited.

Standards and Safety Regulations

To safeguard public health, various organizations have established safety standards and guidelines for NIR emissions. The International Commission on Non-Ionizing Radiation Protection (**ICNIRP**) and the World Health Organization (WHO) provide recommendations on permissible exposure levels to ensure public safety.

1. **Safety Limits**: For electric fields, the recommended safety limit is typically between 1 to 50 V/m, depending on the appliance and its usage. For RF emissions, limits are often set at around 450 $\mu W/m^2$ for general public exposure.

2. **Consumer Awareness**: Regulatory bodies encourage consumers to stay informed about the appliances they use. Understanding the electromagnetic emissions associated with various devices can help users make safer choices.

3. **Manufacturer Responsibility**: Manufacturers are urged to prioritize safety in their design and production processes. Implementing features that minimize NIR emissions in appliances can significantly mitigate potential risks.

Steps for Radiation Awareness and Safety

To foster a culture of safety and awareness regarding NIR emissions, consumers can take proactive steps:

1. **Limit Prolonged Exposure**: When using devices like cell phones and laptops, consider using speakerphone or hands-free options to reduce direct exposure. Additionally, limiting screen time can further minimize exposure.

2. **Maintain Distance**: Keep a safe distance from appliances that emit higher levels of radiation, such as microwave ovens during operation. Standing a few feet away can significantly reduce exposure.

3. **Use EMF Protection Devices**: Many products are available on the market designed to shield against EMF emissions. While their effectiveness varies, they may offer peace of mind for concerned consumers.

4. **Educate Yourself and Others**: Share information and raise awareness about NIR emissions with friends and family. Engaging in discussions about safe practices can foster a community of informed users.

5. **Monitor Appliance Emissions**: Conduct periodic checks on the emissions from common household appliances using EMF meters. This can help identify potential sources of concern and facilitate informed decision-making.

6. **Stay Updated on Research**: As scientific understanding of NIR emissions evolves, staying informed about research developments can help consumers make better choices regarding appliance use.

As technology continues to advance and household appliances become increasingly sophisticated, the importance of radiation awareness cannot be overstated. While non-ionizing radiation is generally considered safe at regulated levels, understanding the sources, potential health implications, and safety regulations is crucial for informed decision-making. By taking proactive measures, consumers can mitigate risks associated with NIR emissions, ensuring a safe and healthy living environment. Through education, awareness, and responsible usage, we can embrace the benefits of modern technology while prioritizing our health and well-being.

Chapter 10

Future Prospect

As technology continues to evolve at an unprecedented pace, the future of non-ionizing radiation (NIR) safety in household appliances presents both challenges and opportunities. With the proliferation of smart devices and increased connectivity, it is imperative to consider the implications of NIR emissions on public health and safety. One of the most significant trends on the horizon is the innovative design of household appliances aimed at minimizing NIR emissions. Manufacturers are increasingly investing in research and development to create devices that incorporate built-in shielding and operate at lower emissions levels. For instance, smart appliances could be equipped with sensors that automatically reduce their emissions when not in active use, significantly mitigating exposure risks. This proactive approach not only enhances user safety but also aligns with the growing demand for energy-efficient appliances, which often correlate with reduced electromagnetic field generation.

In addition to technological advancements, regulatory developments will play a crucial role in shaping the future landscape of NIR emissions. As scientific research continues to advance, regulatory bodies will need to adapt safety standards to reflect new findings regarding permissible exposure levels. Stricter limits on emissions from household appliances may emerge, ensuring alignment with the latest scientific evidence. Moreover, there is a pressing need for harmonized international standards for NIR emissions. Collaborative efforts among countries can lead to unified guidelines that protect consumers while facilitating trade. Increased oversight and compliance measures will likely be implemented, ensuring that manufacturers prioritize safety in their designs and production processes. This regulatory evolution will provide a robust framework for addressing the challenges posed by emerging technologies.

Public awareness and education will also be pivotal in navigating the complexities of NIR emissions in the future. Enhanced consumer education initiatives will empower individuals to make informed choices about the appliances they use. Through digital platforms, community outreach programs, and workshops, information about safe usage practices can be disseminated widely, fostering a culture of safety. Engaging communities in discussions about NIR emissions can further amplify awareness, enabling collective action in advocating for safer appliances. Additionally, health professionals will increasingly play a vital role in educating the public about non-ionizing radiation, providing guidance on best practices for minimizing exposure. As public concern about the potential health effects of NIR emissions grows, the collaboration between healthcare providers and regulatory bodies will be essential in delivering accurate information and addressing misconceptions.

Looking ahead, ongoing research into the health effects of non-ionizing radiation will be crucial for understanding its long-term implications. Continued scientific inquiry will focus on longitudinal studies that assess the cumulative effects of exposure, particularly in vulnerable populations such as children and pregnant women. Interdisciplinary collaboration among scientists, engineers, health professionals, and policymakers will be necessary to develop comprehensive solutions for mitigating exposure while maximizing the benefits of technology. As new technologies, such as 5G and the Internet of Things (IoT), emerge, it becomes increasingly important to investigate their implications for public health. Understanding the unique emission profiles of these devices will inform the development of effective safety guidelines and regulations. By prioritizing safety in the design and use of household appliances, we can harness the benefits of technology while safeguarding public health for generations to come.

Chapter 11

Limitations

The investigation into non-ionizing radiation (NIR) emissions from household appliances provides critical insights into the potential health risks associated with everyday technology. However, like any research endeavor, this study is not without its limitations. These limitations can significantly influence the validity and applicability of the findings, making it essential to recognize and address them for future research. This discussion will explore three primary limitations: physical measurements, lack of cooperation from subjects, and time constraints.

Physical Measurements

One of the most significant limitations of this study pertains to the physical measurements of NIR emissions from various household appliances. The methodology employed was designed to be standardized, ensuring that readings of magnetic fields, electric fields, and radio frequency emissions were as accurate as possible. However, several factors could have inadvertently influenced the results.

Firstly, the placement of measuring devices plays a crucial role in determining the recorded emission levels. Variability in distance from the appliance, the angle of measurement, and the environmental conditions at the time of measurement can all lead to fluctuations in the data. For example, if a measuring device is positioned too close to an appliance, it may capture higher readings due to the concentration of emissions. Conversely, measuring from a distance could yield lower readings, potentially distorting the real exposure levels experienced by users.

Moreover, the presence of nearby electronic devices or metallic surfaces can create interference, further complicating the accuracy of the measurements. Electromagnetic fields can reflect or refract off surfaces, leading to erroneous readings that do not accurately represent the emissions of the appliance being studied. The calibration of measuring instruments is another critical factor influencing the validity of the results. Any discrepancies in calibration could result in either overestimating or underestimating the emissions, which would ultimately affect the study's conclusions.

Additionally, the study's focus on a limited number of appliances raises concerns about the representativeness of the findings. While an array of devices was examined, the results may not comprehensively reflect the emissions from all household appliances, particularly those with unique designs or operating mechanisms. For instance, specific high-tech appliances may have different emission profiles that were not captured in this study. Therefore, the findings could be skewed, limiting their applicability to the broader population of household devices.

Lack of Cooperation from Subjects

Another significant limitation encountered during the study was the lack of cooperation from some subjects involved in the data collection process. Engaging participants to provide accurate information about their appliance usage and exposure levels proved to be a challenging endeavor. Some individuals were reluctant to disclose their usage patterns, while others were simply unaware of how to accurately report their exposure to NIR emissions. This lack of cooperation can lead to incomplete data sets, which can hinder the study's ability to draw definitive conclusions regarding the safety of specific appliances.

The reluctance of participants to engage fully in the study may stem from various factors. Some individuals may have felt overwhelmed by the technical nature of the study, leading them to either misinterpret questions or provide vague responses. Moreover, the subjective nature of participants' experiences and perceptions of NIR exposure could vary widely. For instance, some individuals might have heightened sensitivity to electromagnetic fields, leading them to overestimate their exposure, while others may dismiss potential risks altogether.

This variability in participant responses can introduce bias into the study, making it difficult to ascertain the true emissions experienced by users in real-world settings. Furthermore, the study's reliance on self-reported data regarding appliance usage and exposure times can be problematic. Participants may not accurately recall or report their daily habits, resulting in discrepancies between reported and actual exposure levels. The lack of cooperation ultimately limits the comprehensiveness of the study, which could have benefited from a more engaged participant pool that provided consistent and reliable information.

Time Constraints

Time constraints posed another significant limitation to the study, impacting various aspects of the research process. The investigation was conducted within a specific timeframe, which inherently limited the scope of data collection and subsequent analysis. A more extended study period would have allowed for the exploration of a broader range of appliances, as well as the collection of more extensive data on their emissions.

Moreover, time limitations affected the ability to perform repeated measurements, which are essential for assessing variability and reliability comprehensively. Conducting multiple measurements over time would provide a more nuanced understanding of how emissions fluctuate based on usage patterns, appliance conditions, and environmental factors. For instance, certain appliances may emit different levels of radiation during peak usage times compared to when they are idle or in standby mode. Long-term monitoring could provide valuable insights into the cumulative effects of exposure, particularly in households where appliances are used frequently.

Additionally, the time constraints may have limited the depth of participant interviews or surveys, resulting in a loss of qualitative data that could have enriched the study's findings. In-depth interviews with participants could have revealed important contextual factors influencing their exposure to NIR emissions and their perceptions of potential health risks. Such qualitative insights could complement the quantitative data collected, leading to a more holistic understanding of the implications of NIR emissions in everyday life.

Chapter 12

Conclusion

In conclusion, home appliances have undeniably transformed our daily lives, enhancing comfort, efficiency, and productivity. From the rudimentary devices of early civilizations to the sophisticated smart appliances of today, their evolution reflects human ingenuity and the relentless pursuit of convenience and better living standards. These indispensable household companions have not only revolutionized the way we manage domestic chores but have also significantly contributed to improved health, well-being, and culinary creativity.

The advent of smart technology has further amplified the benefits of home appliances, offering unprecedented convenience and personalized user experiences. However, as our reliance on these devices grows, it is essential to remain mindful of the potential health implications associated with the radiation they emit. Understanding the difference between ionizing and non-ionizing radiation and adopting responsible usage practices can help mitigate risks and ensure our continued well-being.

Looking ahead, the future of home appliances promises even more innovation and sophistication, further enhancing our living experience. As technology advances, we can anticipate new and improved appliances that will continue to simplify our lives, making our homes more comfortable, efficient, and enjoyable. Home appliances, once simple tools, have become integral to modern living, and their impact on our daily lives will undoubtedly continue to be profound and far-reaching.

The findings from various studies underscore the significance of monitoring and regulating occupational and residential exposure to electromagnetic fields (EMFs). The research emphasizes the variability of exposure levels across different industries and environments, highlighting the need for systematic EMF measurements to ensure worker safety. The study conducted at diverse workplaces, including banks, a satellite operator, and a fuel injection factory, revealed significant occupational exposure, particularly in environments with high-power electrical appliances.

Moreover, the discussion on electrohypersensitivity (EHS) and its potential link to EMF exposure adds to the growing body of evidence suggesting that non-ionizing radiation can have adverse health effects. While causation remains a topic of ongoing research, the association between EMF exposure and conditions like EHS and childhood leukemia necessitates precautionary measures. The variability in findings, especially regarding individual susceptibilities to EMFs, points to the complexity of establishing definitive causal relationships.

The reviewed literature also highlights the public's growing concern over EMF exposure due to the proliferation of wireless communication technologies and household electrical devices. This calls for enhanced public awareness and education on EMF safety standards and protective measures.

Overall, the comprehensive assessment of EMF exposure and its health implications supports the urgent need for updated guidelines and regulations globally. Continued research, particularly large-scale longitudinal studies and systematic reviews, is crucial to deepen our understanding of EMF effects and to inform policy decisions aimed at protecting public health.

The pervasive presence of non-ionizing radiation in our modern homes necessitates a deeper understanding of its potential impact on health and well-being. As our daily lives become increasingly intertwined with a myriad of electronic devices—from microwave ovens to Wi-Fi routers and cell phones—the exposure to various types of non-ionizing radiation is constant and unavoidable. While this form of radiation is generally considered less harmful than ionizing radiation, the long-term effects of continuous exposure warrant careful consideration.

Awareness and education are key to mitigating potential risks. By understanding the different types of non-ionizing radiation and their sources, such as low-frequency fields from power lines and high-frequency fields from communication devices, individuals can make informed decisions about the use of these technologies. Measuring power density and considering specific absorption rates (SAR) of devices can further guide safer usage practices.

As we continue to embrace technological advancements that enhance convenience and efficiency in our homes, it is crucial to balance these benefits with mindful practices to minimize exposure. Future research and innovation should aim not only to improve the functionality and efficiency of home appliances but also to enhance their safety in terms of electromagnetic emissions. In this way, we can continue to enjoy the advantages of modern technology while safeguarding our health and well-being.

The potential health effects of near-infrared (NIR) radiation from home appliances remain an area of active investigation. NIR radiation, a type of non-ionizing radiation, is utilized in various medical, industrial, and increasingly, domestic applications due to its purported health benefits, including pain relief, improved circulation, and enhanced skin health. However, the literature reveals mixed results: some studies suggest beneficial effects, while others indicate possible risks such as eye damage and premature skin aging.

The increasing use of NIR home appliances underscores the need for awareness and prudent use. While these devices hold promise for enhancing well-being, it is crucial to adhere to safety guidelines, such as limiting usage time and consulting healthcare professionals before use, especially for individuals with specific health conditions or vulnerabilities. The lack of conclusive evidence on the long-term health impacts of NIR radiation calls for more rigorous and comprehensive research to better understand its effects and establish clear safety standards.

As consumers become more informed about the potential risks and benefits of NIR radiation, they can make educated decisions about incorporating these technologies into their homes. By balancing the advantages of NIR appliances with a cautious approach to their use, individuals can enjoy the benefits of modern technology while minimizing potential health risks. This awareness and responsible use of technology are essential for fostering a safer and healthier interaction with our increasingly electrified environments.

The electromagnetic (EM) spectrum encompasses a wide range of radiation types, each with unique wavelengths, frequencies, and photon energies. This spectrum includes non-ionizing radiation (NIR) and ionizing radiation, with applications spanning from everyday home appliances to medical treatments. Understanding the properties and potential health effects of these various types of radiation is crucial for their safe use.

Non-ionizing radiation, which includes radio waves, microwaves, infrared radiation, visible light, and ultraviolet radiation, generally poses minimal risk at low intensities. However, prolonged or high-intensity exposure can lead to specific health concerns, such as tissue heating, eye damage, and skin conditions. Ionizing radiation, such as X-rays and gamma rays, is more hazardous due to its ability to ionize atoms and molecules, potentially leading to severe health issues like cancer.

The relationship between wavelength, frequency, and the speed of light ($c = \lambda f$) underscores the inverse proportionality between wavelength and frequency, reinforcing the constant nature of light speed across different mediums. This fundamental principle aids in understanding and calculating the properties of electromagnetic waves.

Thermal effects of long-term EM spectrum exposure in home appliances can impact both the devices and their users. Appliances may suffer from reduced efficiency, component failure, and a shortened lifespan due to overheating. Users may experience skin burns, eye damage, and potential health risks from extended exposure to certain radiation types. Implementing strategies such as following usage instructions, ensuring proper ventilation, regular maintenance, and maintaining safe distances can help mitigate these thermal effects.

Overall, while the EM spectrum provides significant technological benefits, it is essential to remain aware of the potential risks associated with different radiation types. Continued research and adherence to safety guidelines are vital for optimizing the advantages of EM radiation while minimizing its health and environmental impacts.

The contemporary household is greatly enhanced by the integration of advanced home appliances, which contribute significantly to convenience and efficiency in daily life. However, the rapid pace of technological innovation in these appliances brings challenges related to performance, safety, and sustainability. To address these challenges, the application of Non-Ionic Radiation (NIR) technology presents a promising avenue for enhancing our understanding and optimization of home appliances.

The research into NIR technology's application to home appliances is significant due to its potential to revolutionize appliance performance analysis, monitoring, and optimization. By leveraging NIR's unique properties, researchers can gain new insights into appliance functionality, durability, and user experience, contributing to more efficient, reliable, and eco-friendly household devices. Moreover, as environmental and safety concerns grow, NIR technology offers a non-invasive and versatile tool for assessing appliance efficiency, detecting defects, and mitigating risks associated with electromagnetic fields.

This study aims to explore the feasibility, efficacy, and implications of using NIR technology in home appliances, addressing key questions about appliance suitability for NIR analysis, the impact of electric and magnetic fields, consumer perceptions, and the selection of appropriate measurement instruments. Through a mixed-methods research design, combining qualitative and quantitative approaches, the study seeks to provide a comprehensive understanding of NIR technology's potential applications and implications.

Ultimately, the insights gained from this research have the potential to inform future advancements in appliance design, manufacturing, and consumer education, fostering a more efficient, sustainable, and technologically advanced domestic environment. By systematically investigating the applications of NIR technology, this study contributes to the broader goal of enhancing the performance, safety, and sustainability of home appliances, aligning with the evolving needs and expectations of modern consumers.

the application of electric and magnetic fields in NIR analysis plays a crucial role in evaluating and optimizing the performance of home appliances. Magnetic fields, inherently present in devices like MRI machines and inductive sensors, can influence home appliances by inducing currents in conductive materials, potentially leading to heating, electromagnetic interference, or component failure. Similarly, electric fields, significant in techniques like dielectric spectroscopy, can impact the electrical properties and performance of appliances by influencing charged particles and dielectric materials. High levels of electric or magnetic fields necessitate careful monitoring and mitigation to ensure safety, prevent interference, and optimize appliance design.

The study's focus on understanding these fields' effects on home appliances is vital for enhancing safety, performance, and regulatory compliance. By analyzing electric and magnetic fields, researchers can develop design modifications, such as shielding sensitive components and selecting appropriate materials, to mitigate adverse impacts and improve appliance reliability. Additionally, compliance with electromagnetic compatibility (EMC) and safety standards is essential for the marketability and acceptance of home appliances, and NIR analysis provides valuable insights for compliance testing and certification processes.

Furthermore, the study's research design, which includes a comprehensive approach to population sampling and data analysis, ensures robust and generalizable findings. By targeting a diverse population of consumers, industry experts, and other stakeholders, and employing rigorous qualitative and quantitative data analysis methods, the research aims to provide a holistic understanding of NIR technology's application in home appliances. The integration of qualitative and quantitative data through a mixed-methods approach enhances the validity and reliability of the results, offering valuable insights into consumer perceptions, appliance performance, and safety implications.

Ultimately, this research contributes to advancing the field of home appliance technology by exploring the feasibility, efficacy, and implications of NIR analysis. The findings have the potential to inform future developments in appliance design, manufacturing, and consumer education, paving the way for more efficient, reliable, and sustainable household devices. As technology continues to evolve, understanding and harnessing the benefits of NIR technology will be crucial in meeting the growing demands for performance, safety, and sustainability in modern home appliances.

Non-ionizing radiation (NIR) emissions from household appliances reveal significant insights into the levels of magnetic fields, electric fields, and radio frequency (RF) emissions across a variety of commonly used devices. The findings underscore the diversity in emission levels, with some appliances consistently adhering to safety standards while others, such as laptops and washing machines, exceeded recommended thresholds, particularly for RF and electric fields.

This research emphasizes the importance of heightened awareness regarding NIR emissions in modern homes. Although many appliances operate within safe limits, certain outliers indicate a potential risk for overexposure. These results suggest a need for more stringent safety standards and improved appliance designs to minimize harmful emissions, especially as technology continues to evolve and permeate everyday life.

The study further illustrates the necessity of continuous monitoring and regulation of household NIR emissions. Increased consumer education is critical to ensure users are informed about the potential risks and safe practices when operating these appliances. Additionally, manufacturers must prioritize the integration of safety features that reduce NIR emissions without compromising functionality.

While most appliances pose minimal risk under normal usage, this research highlights specific areas where improvements are needed to ensure a safer living environment. Future research should focus on long-term exposure effects and include a broader range of appliances to provide a more comprehensive understanding of NIR risks in household settings. By combining consumer awareness, regulatory oversight, and technological advancements, we can better mitigate the risks associated with NIR emissions.

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