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Monitoring Electromagnetic Field Exposures from High Voltage Transmission Lines: A GUI-Based Software System

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ABSTRACT

This study investigates the potential health effects of electrical and magnetic fields generated by high voltage power transmission lines (HVTLs), with a particular focus on farmers who are exposed to these fields in different weather conditions. HVTLs emit low frequency electromagnetic fields that have been shown to be harmful to human health. Therefore, it is important to raise awareness about the risks associated with living in close proximity to HVTLs. The main objective of this study is to develop a GUI-based software system that enables the communication of electromagnetic field exposures using various parameters, including different climate conditions affecting the electric field, the effects of electromagnetic fields on people of different ages, and the identification of areas that require additional safety measures through the development of an appropriate mathematical model. To achieve this goal, the study integrates the GUI with various sensors and user-defined functionality. The developed software system provides valuable insights into the potential health effects of HVTLs by generating output electromagnetic field data that can be used to identify likely disorder statistics. The study utilizes data from reputable sources such as the WHO and ICNIRP to inform the analysis of disorder statistics. The findings of this study contribute to the ongoing discussion surrounding the potential health effects of HVTLs and highlight the importance of developing effective tools for monitoring and communicating electromagnetic field exposures. The developed GUI-based software system represents a significant step forward in this direction, providing a valuable resource for researchers, policymakers, and the general public.

Keywords: High Voltage Transmission Lines; GUI software; diseases; health

INTRODUCTION

By creating populace of the world, towns and urban districts are broadening, various advancements began near high voltage power transmission lines. The improvement of energy demand has extended the requirement for sending monstrous measure of energy over critical distances. Huge transmission lines blueprints with high voltage and stream levels produce enormous extent of electric and magnetic fields stresses which sway the human and the nearby things coordinated at ground surfaces (Younker & Radunovich 2021). This ought to investigate the effects of electromagnetic fields near the transmission lines on human safety (Kulkarni & Gandhare 2014). Electromagnetic field, created by high voltage power transmission lines, are especially huge parts that are by and large considered by power utilities during the lines' arrangement and upkeep (Jan et al. 2023). The fundamental effects of EMF are connected with medical problems because of present moment, midterm and long term exposure of transmission lines and causing a danger for bunches working near HVT lines (Multinove et al. 2008). Normally, electromagnetic fields made by transmission lines cause's extreme effects for both people and metal elements (Yousafani et al. 2023). Assuming that the human bodies are capable to incredible electromagnetic fields, its chief effect is the making of electric field inside the body. Electromagnetic fields

change, in their belongings, when they pass across the gathering of living creatures at low frequencies (Fazdil et al. 2023). An electric field guided on a presented individual conveyances to ground while the magnetic field attacks the body beginning an magnetic transition that produces conceivable electric fields inside the body and after that additionally prompted the flow thickness that causes the difference in protein level in human body, DNA amalgamations, heart brokenness and conceivable apprehensive effects which are truly destructive for people (Hossam-Eldin et al. 2012). Natural change may disagreeably affect power supply adequacy by diminishing the age and bandwidth while simultaneously growing power demand (Bartos & Chester 2015). Most extreme hotness and drought can frustrate power demand, that sway the restrictions of current conveying limit of HVT lines (Sathaye 2011). which caused to increase the peak loads. As air carbon focuses increments, because of high hotness and with higher recurrence, occasions are unsurprising to occur of dry cell, suggesting that power framework may be place beneath more pressure for lengthier time stages (Parry et al. 2007).

Supply of the power plants which works at base burden, which need a trustworthy stock for cooling the water (van Vliet et al. 2012; Harto et al. 2012). Additionally, outrageous warmth could lessen the power yield that are created by the fundamental wellsprings of energy like by utilizing turbine (Koch & Vögele 2009). These cells drop capability when the temperature of air is a lot of high because of expanded transporter recombination rates (Spallina et al. 2013). Due to above reason, it might say that temperature change the ampacity of electrical cable which cause to lessen the magnetic field (Alayat et al. 2023). Additionally, the environmental change likewise sways the electromagnetic fields and different agricultural crops (Zaidan et al. 2023), with different impacts on farmer health and other phenomenas related to farmers (Sarraf et al. 2020).

On the off chance that the air encompassing the guides of HVT lines is filled by raindrops, the permittivity of air is changed over into composite permittivity (Utama & Aliyu, 2018). At the same time the component of the dielectric steady in like manner changes which caused to change level of voltage slope as well as the overwhelmed electric field will likewise be change at ground level. The water drops which are available at the outer layer of separator caused to create flashover or electrical breakdown because of electric field force. Essentially, the pollution and dampness cause the electrical breakdown at present voltage, subsequently impacts steady nature of power movement. According to IRPA rules, the transparency ranges are 30 KV/m pertinent for brief period of time of working day and 10KV/m for whole working day for related exposure (Sirait et al. 1997). In these most recent years, there are complaints connected with EMF impacts which unfavorably cause various kinds of basic health issues. Nonetheless, as indicated by the 21 epidemiological investigations, the augmentation of the gamble of leukemia in youngsters because of caused significant openness of Mf's. The World Health Organization (WHO) distributed a review in June 2007 which depends on the conceivable health impacts happens because of exposure to magnetic and electric field. Word related and overall population EMF openness limits have been laid out by an assortment of global and public associations. The International Commission on Non-Ionizing Radiation Protection, IEEE, and NRPB rules are from these associations. The ICNIRP lays out methods which addresses the solid openness for individuals as well concerning the normal public to the few sorts of non ionizing radiations, with electric and magnetic field. These methods are created utilizing distinct advances and boundaries and depend on existing logical writing. In a few nations, the International Commission on Non-Ionizing Radiation Protection and Institute of Electrical and Electronics Engineers standard associations have been generally perceived and executed (Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz TO 100 kHz)," 2010), (WHO 2007) Just the intense impacts have been distinguished, as indicated by WHO outline area, the IEEE and ICNIRP. Table 1 shows reference levels for general public International Commission on Non-Ionizing Radiation Protection.

The major goal of this research effort is to analyze and calculate the damaging exposure to electric and magnetic fields on people living under HVTL, especially, in rural areas, suffering from extremely subtle effects like various diseases. The solution to these problems is to create a GUI-based model for software that can recognize the effects of different weather patterns on electric field and assess each weather pattern as thoroughly as possible by developing an appropriate numerical model of the electric and magnetic field under various circumstances, in light of distance impact, humidity and temperature impact, and raindrop impact. Utilizing clinical research to recognize the major effects of electric field openings on those working beneath them. Through clinical analysis and with the help of experts, conduct original investigations to look into the types of illnesses people are experiencing who have different exposure ranges and living time lengths from specifically urban regions, such as migraine, disease and leukemia. The illnesses that are found in this information will essentially be compared with the overview types of the ongoing information of these regions, depending on whether or not these infections are looked for locally, and furthermore compared with the WHO's scopes. The

information in the overview structures, such as ampacity, tower height, and conductor count data, will aid in determining the magnetic field and electric field (WHO; 2007). For the purpose of this experiment, EMFs were measured at various sites. These measurements have relevance when compared to the established limitations. This summary provides exposure recommendations for various frequency levels. These recommendations were last updated by the ICNIRP in April 1998(Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz TO 100 kHz)," 2010). As the distance from the instrument or overhead line for transmission lines increased, measurements were made every 10m, and the measured values were recorded. The data we used to produce our calculations is shown in the Table 2 and 3.

TABLE 1. Comparison of Insulators (WHO 2007)

Frequency (Hz)	E-Field Strength E (Kv m^{-1})	Magnetic-Field Strength H (A m^{-1})	Magnetic-flux density B (T)
1 - 8	5	$3.2\ 10^4/F$	$4\ 10^2/F$
8 – 25	5	$4\ 10^3/F$	$5\ 10^3/F$
25 – 50	5	$1.6\ 10^2$	$2\ 10^4$
50- 400	$2.5\ 10^2/F$	$1.6\ 10^2$	$2\ 10^4$
400 – 3000	$2.5\ 10^2/F$	$6.4\ 10^4/F$	$8\ 10^2/F$
3000 - 100000	$8.3\ 10^2$	21	$2.7\ 10^5$

TABLE 2. Comparison of Insulators (WHO 2007)

Exposure	E-Field (v/m)	Magnetic-Field (UT)
Public	5000	100
Occupational	10,000	500

TABLE 3. Magnetic and Electric field Exposure guidelines (WHO 2007)

Distance (m)	E-Field (v/m)	Magnetic-Field (UT)
Below 10	8000	6
10	4000	3
20	1500	2
30	800	10
40	600	6
50	400	3

Electromagnetic fields (EMF), which are released by sources like electric transmission lines, are something that people are constantly exposed to. The impact of high voltage transmission lines on human health is a major source of concern. Due to this exposure, a possible risk for leukemia, breast cancer, cognitive impairments, and reproductive consequences has been noted. Only those who are regularly exposed to radiation, such as those who work in high voltage substations (SS) or spend a lot of time near transmission lines, are impacted by the aforementioned issue. Leukemia in children is a rather uncommon condition. Childhood leukemia affects 4 out of every 100,000 kids between the ages of 0 and 14. Additionally, average magnetic field exposures above 0.3 or 0.4 T in homes are rare (Fernie & Reynolds 2005). These investigations show that children exposed to magnetic fields larger than 0.3–0.4 T had a doubled risk of developing leukemia compared to children exposed to smaller fields. EMFs have been associated with a range of detrimental in vivo effects, such as heart problems, chest pain, and anomalies of the cardiovascular system. The measurements were made in places where high intensity fields were probably present. The weight of the wires pulls them toward the earth in the center of the span. For a 230kV line with a span of 300m, the downward displacement (the wire's sag) is around 11–11.5 meters. Measurements near

and inside selected TLs and SSs are displayed in Tables 1 and 2. These prior results indicate that the field intensity is less than the established criteria at a distance of around 40 m from the TLs. However, there may be a risk for palaces that are outside the borders, particularly for the public spaces like parks where people spend a lot of time. In order to determine how extreme hot or cold weather would affect a transmission line, we gathered data on the effects of temperature on the electric field in general. For instance, an 11 KV line's conductor size will rise and it will expand in hot weather, increasing the electric field. According to the Crown Impact Hazard Study, among the 2.7 million people who live close to high voltage transmission lines, up to 400 additional cases of cellular breakdown in the lungs mortality, 3000 additional cases of cardiovascular and respiratory disease, as well as exacerbated asthma (Lee and J.M; 1982), may occur each year. Here is a thorough breakdown of the unfavorable health effects associated with prolonged exposure to overhead high-voltage electrical wires.

The present study endeavors to examine the outcomes of a hardware arrangement designed to analyze the repercussions of exposure to electromagnetic fields (EMF) on human health. Section 1 delineates the introduction and foundational research conducted in this area of inquiry. Section 2 expounds on the methodology utilized in the development of the software structure. In addition, Section 3 elucidates the software testing and the resultant outcomes obtained from the testing process.

METHODOLOGY

Effect of electric & magnetic field and current density, which has been linked to health effects. Both electric and magnetic fields are formed when electricity is used or when current travels through a conductor. Previously, HVLs were far from residential areas; but, due to country development and rapid population increase, few people currently live near HVLs. For those who do, this will be a significant source of exposure. This EMF radiation is a serious problem for those who live near HVLs, hence we want to make the public aware of the hazard. The WHO issued an evaluation in June 2007 (Standard, 2008) that advised following the ICNIRP's exposure standards.

Many people working under High Voltage Transmission lines or having their residences, especially in rural areas, are suffering from severe invisible repercussions in the form of various diseases as a result of dangerous electric and magnetic field exposures. The electricity system generates an extremely low frequency electromagnetic field, which is classified as non-ionizing radiation and can induce health impacts and dangers, including cancer of various forms. Aside from the human effect, high voltage transmission lines' electrostatic coupling and electromagnetic interference have an impact on plants. Furthermore, It is undeniable that electromagnetic fields above a certain threshold might have biological consequences. It implies that short-term exposure to contaminants found in the environment has no discernible negative consequences. Higher amounts of exposure that could be detrimental are limited by national and international guidelines. As evaluated by shoot length, root length, leaf area, specific leaf weight, shoot/root ratio, total biomass content, and total water content, the crop's response to EMF from 11 KV and 500 KV Power lines dramatically reduced the growth of the four crop plants compared to the control plants.

After making the necessary calculations, it will be able to actually determine what will happen to the transmission line if it is raining, foggy, or has dew drops. The outcomes of these calculations will typically compensate for the mathematical model. In order to compute the distance impact on power transmission lines, which explains how changes in distance produce changes in the electric field, magnetic field, and current density, we create an appropriate mathematical model. A horizontal 500KV single circuit arrangement, for instance, has three conductors and uses the central conductor as a reference point "O." Here, "s" represents the distance between two conductors, "R" represents the distance from any point of reference, "I" represents the transmission lines' ampacity, and "r" represents the angle between "R" and the horizontal central line.as shown in Figure 1.

The ampacity **'I'** flow through the conductor and the provied condtor resistance determine the amount of heat gained as a result of electrical loading. For the calculations of electric field (E), magnetic field (B) and current density (J) of single circuit and double circuit high voltage power transmission lines on different effects i.e, temperature, distance and raindrop. The designed system is composed of three main levels, as illustrated in Figure 2. At the first level, users are required to provide basic information pertaining to the site in question. Subsequently, at the second level, sensors that are connected to the system are able to acquire data from the site, which is then transmitted to the third level for processing. At this stage, the compiled data is analyzed, and a report is generated which provides an overview of the impact of the electromagnetic field on the site under investigation. The report generated at the third level is expected to provide valuable insights and information, which can be used to make informed decisions and to implement suitable mitigation measures to address any identified issues. The designed system thus offers a comprehensive solution to the complex problem of

assessing the impact of electromagnetic fields, and is expected to be a valuable tool for stakeholders in various industries, including telecommunications, energy, and environmental management.

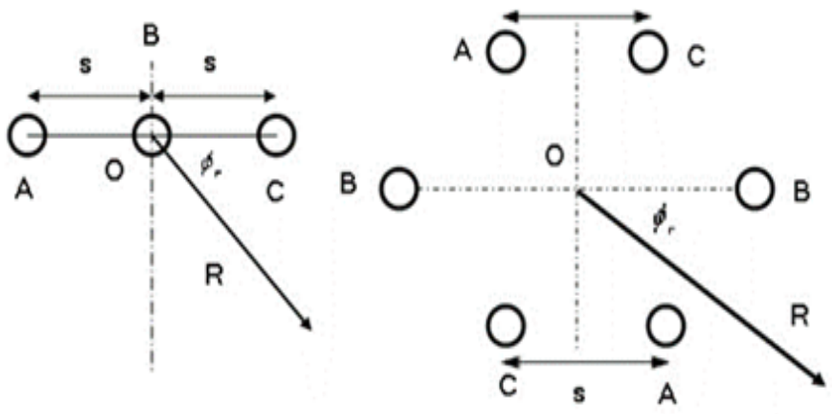

FIGURE 1. Arrangement of conductors on HVTL, (a) Horizontal single circuit configuration (b) Double circuit configuration

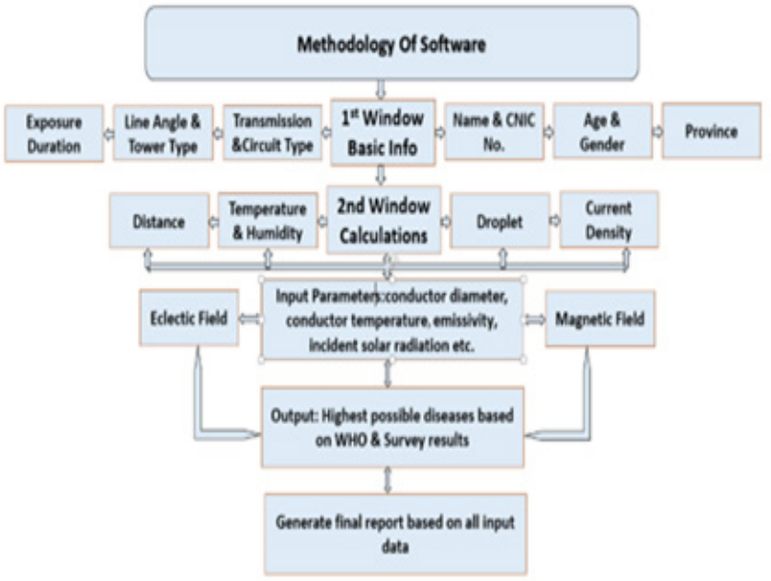

FIGURE 2. Methodology of designed software

DATA WINDOW

The software's front window displays personal and technical information, such as the user's name, CNIC number, age, gender, and province. Technical information includes the transmission type in KV, circuit type (single or double), exposure duration, line angle, and twin bundle capacity. The software also has a button labeled "enable sensor," which activates attached sensors, and a "disable sensor" button, which deactivates them. The forward button allows users to proceed to the subsequent window, while the reset option restores data. Figure 3. Shows the basic front window of the designed software.

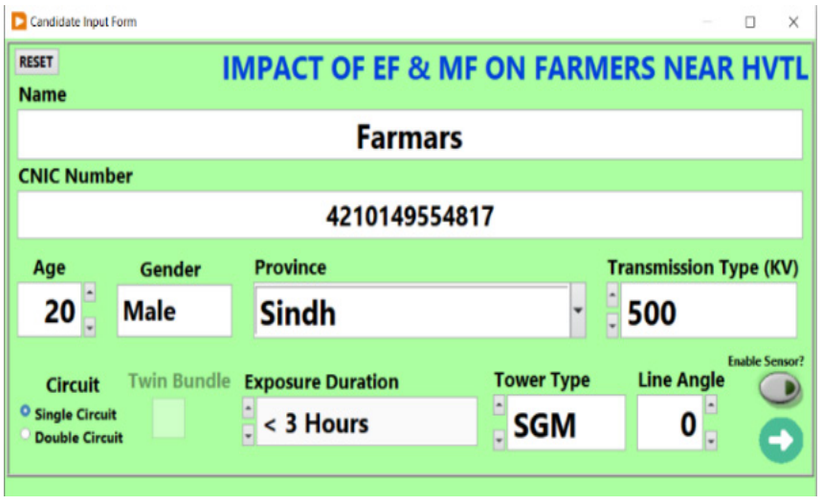

FIGURE 3. First window of software having Personnel & Technical inputs

TEMPERATURE AND HUMIDITY WINDOW

In figure 4 the second level tab is depicted, users can customize the settings to calculate various parameters, such as electric field, magnetic field, humidity, ambient temperature, and current density. The distance between two conductors is denoted by S, which may vary depending on the location and country. The average heat transfer coefficient is denoted by h and is calculated based on the temperature difference (t) between the higher and lower temperatures and the area of the heat transfer surface (F). Solar radiation, also known as "worldwide radiation," refers to the sun-powered energy that strikes the earth's surface.

The absorptivity, which determines the ratio of incident solar radiation that is absorbed by a conductor to that which is reflected back, can vary depending on the material's age and surface conditions. Emissivity, on the other hand, is the ratio of energy emitted from a material's surface to that emitted by an ideal source (a "blackbody") at a comparable temperature, frequency, and review environment. The conductor temperature must be higher than the ambient temperature. The diameter of the wire and its radial distance can also be adjusted. Conductivity is another important factor that determines how a material behaves under power. It is defined by the ratio of the flow's thickness in the material to the electric field that drives the flow. All the factors mentioned can be calculated and measured at the same time.

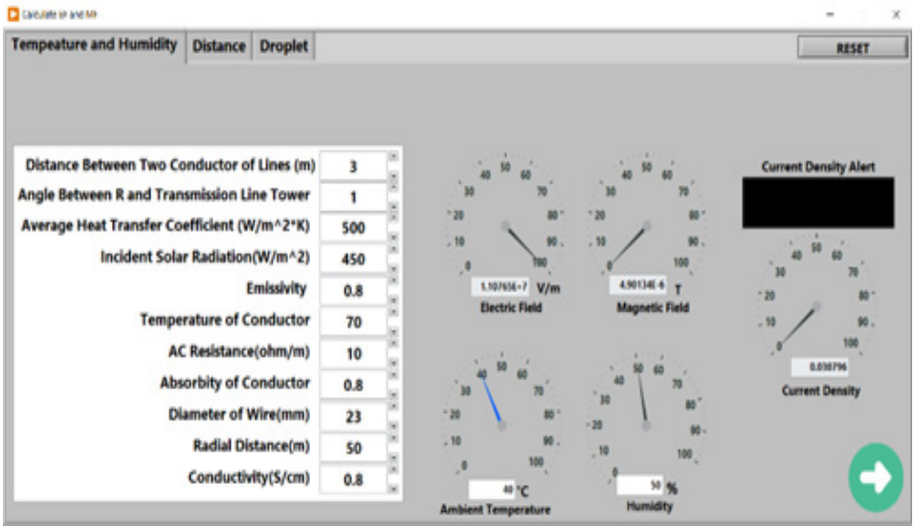

FIGURE 4. Second window of software having Temperature & Humidity calculation inputs & outputs

DISTANCE WINDOW

In figure 5, the primary parameter window is showed is distance and current density measurement, which uses an ultrasonic sensor to show how far away any point of interest is It basically measures the distance from any area of your body, such as your head to the conductor that is closest to you.The term “Current Density” which is expressed in amperes per square meter, refers to the amount of electric current that passes through each cross-sectional area in a unit. The current density will increase as a conductor’s current increases. However, different sections of an electrical conduit experience different current density and higher frequency rotating flows have a greater impact. This window will calculate the current density based on the data acquired from ultra sonic sensor that measured the distance from the human body to transmission line.

FIGURE 5. Third Window for Current Density calculation inputs & output

In the droplet tab of the software, there are three parameters that can be adjusted shown in figure 6. The software calculates the distance between the earth and the point of reference, as well as the distance between the point of reference and the first conductor, which is greater than 2. The software displays the current density warning, indicating whether the current density is higher, equal to, or lower than the set point. The current density warning is color-coded; red represents high current density, while black represents low current density. The software allows users to view any point of interest at a distance based on the radial distance (R). Changes in the ampacity, field, and ambient temperature cause variations in temperature. Changes in the droplet occur as the composite permittivity varies. The software provides a feature for changing a droplet’s composite permittivity.

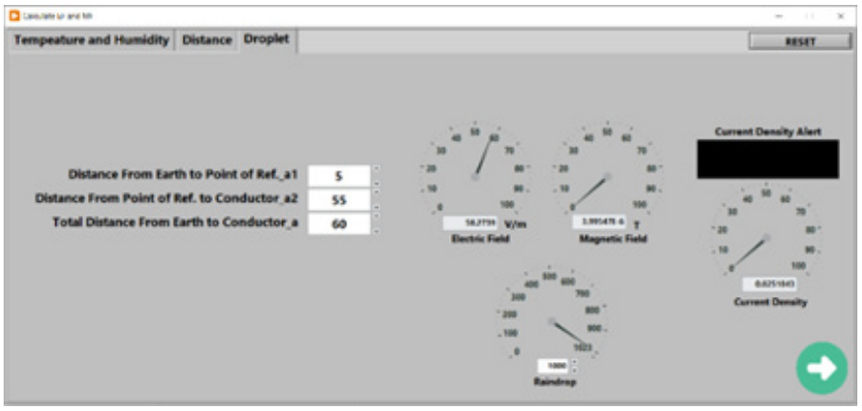

FIGURE 6. Third Window for Current Density calculation inputs & output

RESULTS AND DISCUSSION

The calculation aspect of this research involves analyzing the given data to determine what types of diseases may be medically possible at a given electric field intensity, which is of great significance. By comparing the results of these calculations to existing medical studies, it can be determine which diseases are likely to occur in the area. For example, if the transmission line has a voltage of 11KV and a magnetic field of 1 uT, software can identify the potential diseases that may arise from exposure to these conditions. To validate these findings, it will compare the data obtained from these calculations to real-time data gathered from survey forms, including information on the current, tower height, and number of conductors. Finally, it will compare the electric field intensity calculated from the given data to the electric field intensity obtained from the real-time data to ensure the accuracy of our results.

Diseases For WHO	Survey Based Data		
	Male		
	Short Term Problems	Mid Term Problems	Long Term Problems
	less than 3 hours	B/W 3 to 7 hours	more than 6 hours
Leukemia	Depression/ Headache	Depression/ Headache	Depression/ Headache
Depression/ Headache	aches and pain lethargy	Anxiety attacks	Mood and alertaness
Cognitive Sleep	hypersensitivity	Depression	Aches and pain lethargy
Cardiovascular Disorder	Memory Proplem	Difficult to conc	Difficult to conc
Mood and Alertness	less clear mood	Memory problems	Tumor
Miscarrage/ Early pregnancy loss	Anxiety attacks	Cognition sleep	Cognition sleep
	cognition sleep	Hypersenstivity	Headache
		Less clear mood	less clear mood
Female			
Short Term Problems	Mid Term Problems	Long Term Problems	
less than 3 hours	B/W 3 to 7 hours	more than 6 hours	
Depression	Difficult to conc	Difficult to conc	
Leukemia	Leukemia	Miscarrage/ Early pregnancy loss	
Eye irritation	Cognition sleep	Memory problems	
Memory problems	Depression	Less clear mood	
Anxiety attacks	Anxiety attacks	Cognition sleep	
Headache	headache, less clear mood	headache	

FIGURE 7. Survey based data for male & female

The candidate information is comprised of the user-provided identifying data in the first tab, while the live period can last between less than three hours to up to seven hours. Technical information contains the technical data of the transmission line, including the line angle which varies according to the type of tower. For example, the SGM tower has a line angle of 0 to 1 degree, and any alteration to this angle could result in an error. The survey button provides a list of the most common and least common diseases based on surveys conducted in various geographic locations. If the survey button is not activated, the disease possibilities a sourced from research papers. The highest and lowest possible diseases a person can suffer from are listed under the top and bottom sections respectively, based on the mentioned conditions. Upon selecting "produce report," a report is generated, which contains all the possibilities along with the candidate and technical information.

In order to ensure the accuracy and reliability of our software, a survey was conducted, which involved the collection of real-time data and the interfacing of our hardware with the software. This enabled us to measure various values of electric field, magnetic field, and current density in different scenarios. These values were then compared with the WHO referred values of electric field, magnetic field, and current density, revealing minimal differences between them.

Once the final report was generated based on the real-time input data, we consulted with residents and inquired about their routine-based diseases. This data was then compared with the WHO referred diseases, which resulted in the identification of similar diseases in the surveyed area. The survey enabled us to validate the accuracy of our software, as the measured values were found to be consistent with the WHO referred values. In addition, the comparison of the diseases prevalent in the surveyed area with the WHO referred diseases confirmed the reliability of our software. Figure 8 shows the image for software testing with hardware sensor interfacing at site having HVTL installed.

FIGURE 7. Site location for software testing with hardware interface

CONCLUSION

This study aimed to investigate the potential health effects of electromagnetic fields generated by high-voltage power transmission lines (HVTLs) on human beings who are exposed to these transmission lines in various weather conditions. The study successfully developed a GUI-based software system that integrates various sensors and user-defined functionality to communicate electromagnetic field exposures using different parameters, including climate conditions affecting the electric field, the effects of electromagnetic fields on people of different ages, and the identification. The findings of this study contribute significantly to the ongoing discussion surrounding the potential health effects of HVTLs and highlight the importance of developing effective tools for monitoring and communicating electromagnetic field exposures. The developed GUI-based software system represents a significant step forward, providing a valuable resource for researchers, policymakers, and the general public. The findings of this study will help raise awareness of the risks associated with living near HVTLs and promote the adoption of appropriate safety measures to mitigate these risks.

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DECLARATION OF COMPETING INTEREST

None.

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