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Effect of High Voltage Transmission Lines on Human Health, Plant Life, and Animal Activity

Anirudh Balaji

Student , Electrical and Electronic Engineering, Rajalakshmi Engineering College,
Chennai, Tamil Nadu, India

Abstract- Due to increase in energy cost of transmission and new sources of energy, high voltage transmission becomes the most economical for the transfer of large amounts of electrical power because the higher the transmission voltage, the more efficient and cheaper the transmission. Due to increase in population, the towns are expanding, and naturally result in the construction of buildings near high voltage power lines. Simultaneously, the related public health and other detrimental effects on human, plant, and animal health crop up. This paper outlines the health effects of high voltage AC transmission and high voltage DC transmission on humans, plants, and animals based on epidemiologic studies. Due to increase in power demand because of population explosion, the need for transmitting huge amounts of power over long distances has increased. This paper gives the reader an in-depth analysis of all the effects of high voltage transmission on any living being. There are long-term effects and short-term effects on all living beings. Large transmission lines with high voltage and high current levels produce electric and magnetic field in the neighborhood. This paper also describes, in detail, the effects of magnetic, electric field, and electromagnetic field on human life, animal life, and plant life. This paper also elucidates on the methods to reduce the adverse effects caused by these fields. There are many supporting documents and research papers in favor of and against the harmful effects of these high voltage transmission lines. Therefore, there is a controversy discussion regarding these effects, involving government regulation policy and power companies.

Keywords: high voltage, AC Transmission, DC Transmission, health effects of high voltage, line

shielding, grounding, compaction, human health, plant health, animal health.

1. INTRODUCTION

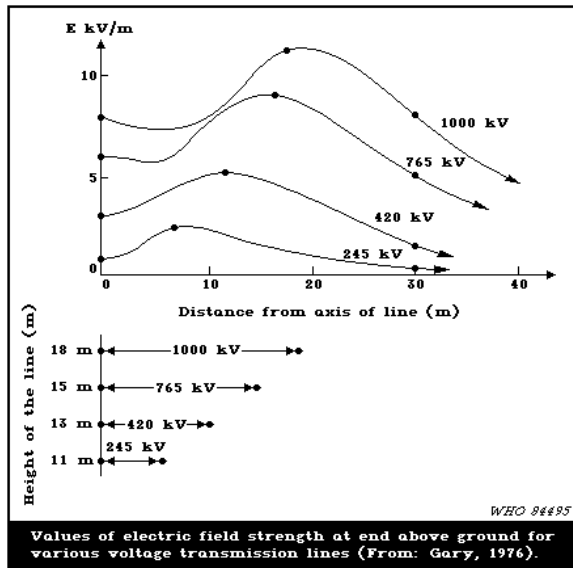
There are two fields associated with a transmission line. They are: electric field and magnetic field. Together, they are called as electromagnetic field or EMF. They occur naturally as a result of power generation, power transmission, power distribution and use of electric power. Each has its own effects on the health of different living organisms and they are discussed in detail in the upcoming paragraphs.

1.1. ELECTRIC FIELD

Electric field exists whenever a positive and negative electrical charge is present. They exert forces on other charges within the field. The strength of the electric field is measured in Volts per Meter V/m or in kV/m. The intensity of the electric field depends upon the following factors:

- Actual transmission voltage
- Distance between conductors in the ground.
- The phase spacing if you have two circuits next to each other as well as geometric configuration of the conductors.
- By the surrounding environment like tall objects such as trees, skyscrapers, fences, etc.
- The transmission center line tangential distance.

- The elevation of the point of measurement



with respect to ground.

Chart 1: Effect of Voltage at different distances from axis of line

The electric field in a power line varies very little because the voltage essentially remains constant.

Each power line runs along a corridor of land called easement. The width of the easement is determined by the electrical load on the system. Public access to an easement is permitted but building and long term occupation are not allowed. At the edge of the easement, the EMFs are appreciably lower than at the center. The WHO limits are not exceeded anywhere within the easement. The EMFs outside the easement are consequently well below these limits. For example, for a typical 330kV transmission tower, the easement width is 60m.

Note: The electric field exists even when there is no current flowing.

1.2. MAGNETIC FIELD

The magnetic field from a power line can vary widely because the current in the wires depends upon the amount of power consumed. There are two basic 50Hz magnetic field, passive magnetic field and

active magnetic field. The magnetic field depends on the following factors:

- The ratings of current passing in the conductors. For example, typical lines-average current of 700A, largest line- average current of 4000A.
- Clearance of the line. We observe that maximum field occur underneath the conductor, and falls rapidly with distance on either side.
- Phasing of the conductors like conductor spacing, phase positioning, and phase balancing affects the magnetic field. The phase positioning are of two types, untransposed phasing and transposed phasing. Untransposed phasing is where the phases on both sides of the line are in the same order from top to bottom and we have a magnetic field which decreases with inverse-square of the distance. Transposed phasing is where the phases of one side are opposite order to the others on the second side. The magnetic field decreases inversely proportional to the cube of the distance.

Magnetic field are the result of motion of electric charge or current when there is a current flowing through a power line. The magnetic field lines run in circles around the conductor. The magnetic field are usually measure in Tesla.

2. ELECTROMAGNETIC FIELD EFFECT ON HUMAN BEINGS

The human body is composed of some biological materials like blood, bones, brain, lungs, etc. The permeability of the human body is equal to the permeability of the air, but **within the human body** it has different electromagnetic values at a certain frequency.

The human body also contains free electric charges which are ion rich fluids like blood and limb, which move in response to forces exerted by charges on and currents flowing in nearby power lines. This process

that produce these body currents are called electric and magnetic induction.

In electric induction charges on power line attract or repel free charges within the body (our body contains both positive and negative charges). Since the body fluids are good conductors of electricity, charges in the body move to the surface under the influence of electric force. For example, a positively charged overhead transmission line induces negative charges to flow through the surfaces on the upper part of the body. Similarly, negative charges induces positive charges. Therefore, the charge on the power lines alternates between positive and negative many times in a second and the charges induced on the body surface also alternates, i.e., negative charges induced in the upper part of the body at one instant flow into the lower part of the body at the next instance. The power frequency electric field induce currents in the body (eddy current) as well as charges on its surface.

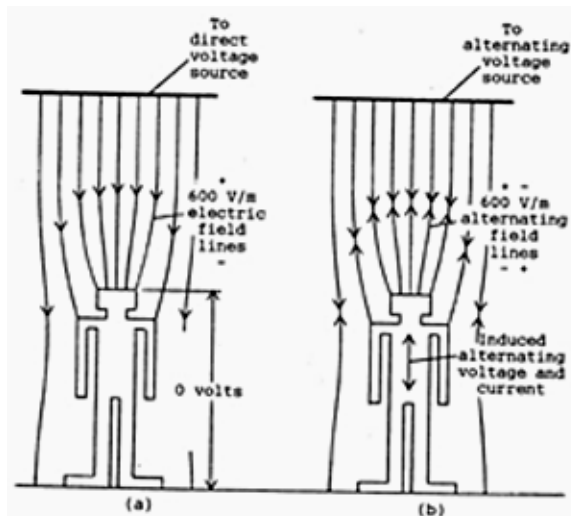


Chart 2: Field lines passing through human body

Magnetic induction: The current induced in the body by magnetic field are greatest near the periphery of the body and smallest at the center of the body.

- Magnetic field induces a voltage in the tissue of human body, which causes a current to flow through it due to its conductivity.

- The magnetic field has the influence on the tissues of the human body, these maybe beneficial or harmful depending upon the nature.
- The magnitude of the surface charge and internal body currents by any given source of power frequency depends upon many factors. For example, this includes magnitude of the currents and charges in the source, the distance of the body from the source, the presence of other objects that might shield or concentrate the field and the body posture, shape, and orientation. For this reason, the surface charges and the currents, which a given field induces are very different for different human beings.
- When a person who is isolated from the ground by some insulating material, comes in close quarters to an overhead transmission line, and electrostatic field is set up in the body of the human being whose ordinary resistance is about 2000Ω . When the same person touches the grounded object, it will discharge through his body causing a large current to flow through the body. Discharge currents from 50Hz electromagnetic field are weaker than natural currents.
- For human beings the limit of the undisturbed field is 15kV/m RMS to experience possible shock.

2.1. SHORT TERM HEALTH PROBLEMS: High power lines emit high levels of electromagnetic radiation. These hazardous man-made EMFs interact in a destructive way with natural electromagnetic fields that exists within human beings. They interfere with cell function, break DNA strands, and erode the immune system. These biological irregularities cause initial symptoms such as dizziness, fatigue, headaches, nausea, and digestive disorders. They often culminate in causing more serious disorders in children, pregnant women, and elderly people.

2.2. LONG TERM HEALTH PROBLEMS: Overhead high voltage power line causes ionization of air emitting trillions of corona ions into the air per second. These ions get attached to the aerosol particles of many types of

carcinogenic air pollution like diesel exhaust, flame retardants in furniture, unintentional by-products of industries, etc. The charged pollution particles are then carried by the wind up to 7kms downwind of the power line and deposit in the lungs at a significantly greater rate than uncharged pollutant particles. The analysis of corona effect risk shows that up to 400 excess cases of lung cancer mortality and 3000 excess cases of cardiovascular and respiratory illness and aggravated asthma may occur annually among 2.7 million people living within overhead high voltage lines. The following is an exhaustive list of negative health outcomes with overhead high voltage power lines exposure over an extended period of time:

- Variety of childhood and adult cancers
- Childhood and adult leukemia
- Alzheimer's disease
- Suicide
- Depression
- Stress
- Specific types of heart disease
- Tumor growth
- Skin growth
- Abnormal cell activity
- Impairment of perception and memory
- Genetic defects
- Gland production deficiency
- Mental and behavioral problems
- Immune system deficiency
- Nervous system disorder
- Birth defects
- Miscarriages
- Stunting of growth
- Fatigue
- Headache
- Nausea
- Decrease in visual and motor reaction time
- Male sexual dysfunction
- Aggravation of asthma
- Sleep deprivation
- Electromagnetic hypersensitivity

Many scientific and medical studies show that higher risks of childhood leukemia are found in children living near overhead lines.

People who live, work or attend school near have increased risk of contracting cancers of different types.

Alzheimer's disease and dementia have been directly linked to exposure of high voltage overhead lines. The risk of Alzheimer's increases to 4.9 times and dementia to 2.5 times the normally expected rate.

3. EFFECT OF ELECTROMAGNETIC FIELD ON ANIMALS

Exposure to high voltage power lines, EMF results in decrease of 5% in milk yield, 13.8% in fat corrected milk yield, and 16.4% in milk fat among the cows. High voltage power lines cause breathing problems and weakened system in cows and pigs. High voltage power lines cause abnormally low pig birth rate, and high piglet mortality, and undersize heifers, and some afflicted with hemorrhages or abortions. Dogs and cats exposed to high EMF levels are still born and deformed puppies and kittens and have abnormal un-breed able seasons, and show risks of lymph cancer 6.8 times the expected rate. Animals kept below high electrostatic field acquires a charge and when they try to drink water, a spark usually jumps from their nose to the grounded pipe. Like hens are unable to pick up grains because of chattering of beaks and it also affects their growth.

4. EFFECT OF ELECTROMAGNETIC FIELD ON PLANTS

The electromagnetic field from high power transmission lines affects the growth of plants in agricultural and forest lands near high power transmission lines. Current in power transmission lines varies according to the load. Hence the effect of EMF due to the current flowing upon the growth of the plants under high power transmission lines remains unaltered throughout the year. From various practical studies, the growth characteristics like shoot length, root length, leaf area, leaf fresh weight, specific leaf weight, shoot/root ratio, total biomass content, total water content of the crop plants were reduced significantly. Similar trends were observed

in the biochemical characteristics like chlorophyll. Reduced growth and physiological parameter was primarily due to the effect of cell division and cell enlargement. Further, there was a stunt in the growth, which is due to poor action of hormones responsible for cell division, and cell enlargement. Conclusively, the biochemical changes produced in the plant due to EMF affects the production leading to economic loss.

5. REDUCTION OF EFFECT OF EMF

- 5.1. LINE SHIELDING:** There are two basic 50Hz magnetic field reduction methods, passive and active. Passive magnetic field mitigation reduction includes rigid magnetic shielding with ferromagnetic and highly conducting materials and the use of passive shield wires installed near transmission lines that generate opposing cancellation field from electromagnetic induction. Active magnetic field reduction uses electronic feedback to sense a varying 50Hz magnetic field and generating a proportionally opposing cancellation field within a defined area surrounded by cancellation coils. This technique is successful in both residential and commercial environment to reduce the magnetic fields from overhead transmission and distribution lines.
- 5.2. LINE CONFIGURATION AND COMPACTION:** Line compaction brings the conductors close together keeping the minimum safe phase to phase spacing constant. The magnetic field is proportional to the phase to phase spacing. By increasing the distance between phases, by increasing the height of the central phase of the conductor above the level of the other phase conductors, leads to the reduction of the peak value of the magnetic field (as shown in figure below).

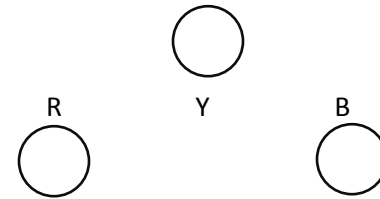


Chart 3: Configuration of lines and compaction

Reducing the phase to phase distance, leads to decrease of the magnetic field. This reduction between the phases is limited by the electrical insulation level between phases. For single circuit lines, and double circuit lines, compaction causes a great reduction in the maximum magnetic field value

- 5.3. GROUNDING:** The grounding of metal objects such as fences that are located on the right-of-way (ROW) eliminate these objects as sources of induced current and voltage shocks. Multiple grounding points are used to provide alternative paths for induced current flow and reduce nuisance shocks.
- 5.4. PROVIDING RIGHT-OF-WAY (ROW):** overhead transmission system require strips of land which are called right-of-ways. These strips of land are usually evaluated to decrease the effects of energized line.
- 5.5. MAINTAINING PROPER CLEARANCE:** Unlike fences or buildings, mobile objects such as vehicles and farm machinery cannot be grounded permanently. Limiting the possibility of induced current from such objects to persons is accomplished by maintaining proper clearances for above ground conductors.

6. CONCLUSION

The research on electromagnetic and different mitigation technique discusses the different equations that allow us to calculate the magnetic fields as well as health effects of the EMF, in general. Values of magnetic fields are obtained by using field work measurement as well as finite element method

simulation using MagNet and MATLAB software for single conductor and three conductors in different configuration as well as for double typical circuit. Further analysis on this topic will help us to completely eradicate the negative effects high voltage transmission lines on the health hazards of human beings and animal life and growth of the plants, which is a challenging feature for young technocrats in future.

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