Effect of Electromagnetic Radiations Due to High Voltage Transmission Lines on Human Beings

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Abstract: *In this paper to satisfy the increasing demand of electricity, the utilization of overhead High Voltage Transmission lines (HVTL) is used in full swing. The HVTL produces an electric and magnetic fields which combine gives electromagnetic radiations. The electromagnetic radiation so produced by the HVTL exerts various impacts on the human body. The long term exposure to the electromagnetic field [EMF] which is emitted by HVTL leads to tremendous possibility of the workers and the residents living in the vicinity of that area of HVTL to experience health related issues like fatigue, neuropsychological disorder such as depression and adverse anxiety issues, which could be extremely hazardous in the upcoming future due to the prolonged exposure without proper awareness. Due to the increase in supply demand and being neuroscience about the effects of HVTL the problems are becoming even more dangerous and this could result in serious & long term problems.*

Keywords: Electromagnetic field, Electric field, Magnetic field, High Voltage Transmission Lines, Human health

1. Symbols

Symbols	Expansion
A	Ampere
B	Magnetic flux density
C	Coulomb
E	Electric field
H	Magnetic field
Hz	Hertz
KV	Kilovolt
V	Volt
m	Meter
mA	Mili-ampere
mT	Mili-tesla

2. Introduction

Many type of research and work has been done on the electromagnetic radiations and has been proved that affected on human beings. When the flow of electricity is initiated in a transmission line, the space around the wire becomes filled with an electric field and magnetic field. When the flow of electricity is initiated in a transmission line, the space around the wire becomes filled with energy. Today power demand is increasing due to increases in population, construction a building is increased. The electromagnetic radiations from high voltage transmission lines have been hazardous for human beings. It not only affects human beings but also plants health. The induced current in a human body by a 50 Hz electric field of HVTL has been studied by many researchers [1, 2]. As health of human beings gets affected from increase in electric field and current in the body as told by Grandolfo et al. 1985 [3]. The increase in population has accelerated the demand for the electricity consumption, so to cope with the increased demand in consumption of electricity the installation of the HVTL has been accelerated mainly in the urban areas. This leads to the increase in the exposure to the EMF radiations emitted by the fields produced around the HVTLs. The field so generated could give hazardous outcomes in terms of health- related matters. The prolonged exposure to the EMF so produced by HVTLs

could have a huge impact on the health which gives room to certain biological effects such as the possibility of neurobehavioral functionality disorder in children [4], not only the neurobehavioral functions but the growth rate in living beings is also adversely affected [5]. Certain neuropsychological disorders are also observed such as poor mental coordination and other psychiatric symptoms [6]. The effects of the exposure to the EMF are so clinically adverse that it has shown the severe outcomes that could approve the effects of EMF on comes induction, however, the effective mechanism in this process are still unknown[11].

Electric field
Now a day's artificially generated electric field has more than the natural field at 50 to 60 Hz. The flow of charges or electrons through a conductor is known as electricity. When electricity flow through power line reached the houses and used by the human beings. It is called the alternating current. An electric field is a field of around the charge particles. The electric field is passed through a material, buildings, and humans. The electric field moves from positive to negative charge. The electric field composed by HVTL, measured in volts per centimeter and electricity flow through a conductor is measured in ampere. The flowing of electric current in the conductor, as well as volume, is increased. So the strength of conductor is also increased. The electric field at a distance r away from a point charge Q is given by

$$E = KQ/r^2 \quad (1)$$

Where, $Q = 1.6 \times 10^{-19}$ coulomb

$K = 8.99 \times 10^9 \, N\,m^2/C^2$

Magnetic Field:-
The Magnetic field is a field of force surrounding a permanent magnet or moving charged particles. The Magnetic field is easily passed through an object such as walls. Magnetic field lines do not stop or start anywhere they make a closed loop and will continue inside a magnetic material. As soon as devices are turned on, it produces a magnetic field which makes a closed loop surround it. When

it is turned off, the magnetic field will be disappear. The magnetic fields are not decreased by trees, buildings such as walls; the field passes easily through these barriers. The Magnetic field is measured in Tesla.

The electromagnetic radiations are considered in the environment where there is no obstruction to them. But it is a very unfair circumstance a correction to it electromagnetic field should be calculated in the presence of human beings. Hence the undisturbed magnetic field may be different as compared to with the presence of humans. There are many biological impacts found on the human body due to the magnetic field.

Electric Field Limitations

In installation of the High Voltage Transmission Lines (HVTL) the electric field should be limited by the safety distance with respect to the conductors. In different values different limiting values exist for distance from conductors. International Radiation Protection Association (IRPA) in close collaboration with World Health Organization (WHO) has derived standards for the time person stay under the electric field [7] from the HVTL as below:

1) For the employers in the field, the time is given by $t = 80/E$ (10<E<30; E in KV/m; t in hours)
2) For the general public the limiting value is 10KV/m if the exposure is only a few hours per day and may be increased if the time is shorter. The limiting value in open space is 5KV/m where it is feasible to remain for a longer period. Hence it can be concluded that there is no noticeable harmful effects in humans to the electric field ranging between 8KV/m to 15 KV/m[8].

Magnetic Field Limitations-

The magnetic field from High Voltage Transmission Line should be minimised safety distance with respect to the conductors. There are different values of distance from conductors for the employers and general public.

1) Magnetic field should not be more than 0.5mT for a employers working whole day near the High Voltage Transmission Lines. Magnetic flux density of 25mT is an allowable limb.
2) A continuous magnetic flux density of 0.1mT is harmful for general public. This restriction is applied to more common areas where general public are found to spend quality amount of time every day [9].

Vital information regarding the exposures required for professional and general population for 50Hz or 60 Hz for electromagnetic field is given in the table no. 1.1

Table 1.1: Exposure limits for 50 or 60 Hz electromagnetic field for human beings [10].

Exposure characteristic	Electric field strength (kV/m)	Magnetic flux density (mT)
Occupational		
24 hour job	10	0.5
Short term job	30	5
For limbs	-	25
Gen General public		
For 24 hrs./day	5	0.1
Few hrs./day	10	1

Table 1.2: Data obtained as per simulation result for human being of height 1.83 meters and standing under the overhead line [11]

S.N.	Test Condition	Electric field (E) in V/m	Electric potential (V) in KV	Magnetic flux density (B) in mT	Magnetic field (H) in KA/m
1.	Agricultural land (220KV)	5810	19.5	2.92	2.32
2.	Coastal Land (220KV)	6000	19.54	2.92	2.32
3.	Sandy land (220KV)	5506	19.7	3.02	2.40
4.	No human(220KV)	17220	32	2.9	2.32
5.	No clearance (220KV)	8400	28	4.65	3.7
6.	132KV	4500	15.5	3.9	3.11
7.	400KV	8520	29.5	3.88	3.1

Electromagnetic Radiations

Electromagnetic Radiations consist of electromagnetic waves which produce a both an electric field and magnetic field. The EMR takes various types of form such as microwaves, radio waves, gamma rays and X-Ray etc. The EMR is created when electrons move, is accelerated by an electric field. The EMR is additionally the movement of energy. The electric and magnetic waves have oscillations that are oriented 90 degrees from each other. The EMR travels through free space or through a material medium in the form of electromagnetic waves, with speed of light. There are several sources of electromagnetic radiation, both natural and artificial.

Effects of EMR on human beings

The EMF has two main components an electrical as well as the magnetic field, the effects of the electrical field can be minimized to a great extend using seriously extensive measures but the magnetic field is more treacherous as it has the ability to penetrate the human body . The extent and the strength of this magnetic field so going on depends on three parameters which are the configuration of the conductor wires, the amount of current flowing and the amount of voltage flowing in the lines and via conductor wires.

Human body gives different responses based on different situations and those response characteristics depends on various factors which are based on age, gender, body type, immunity system. The limit to which a human could bear electric current to a certain amount also varies with respect to the parameters as mentioned above. So the experiments and analysis performed so far aren't accurate enough to prove the hypothesis regarding the various health related questions and issues that have been raised regarding the effects of the electromagnetic radiations which are emitted or generated by the overhead high voltage transmission lines. The people who are mostly affected by the EMF radiation so emitted by HVTLs are those who are either living or working in the surrounding of the installed and working overhead HVTL s.

The electromagnetic radiations from HVTL are seriously affecting the health of individuals in urban and residential communities. The EMR is hazardous to living under the HVTL and other power transmission network increases a

risk of cancer and other health problems. When human beings come near the overhead transmission lines the electromagnetic field is usually set in the human body, with a resistance of approximately 200 ohms. In comparison to a natural current in the body discharge current from the electromagnetic field of 50-60 Hz are weaker. For the human body, the undisturbed field limit is 15kv/m, R.M.S. in order to experience or feel a possible shock. The radiation sickness in an affected person can show the symptoms within few hours and may last for a few months or more .The health hazards of the EMF radiations emitted could be further divided into long term and short term effect , again these effects and there stages of being affected varies from person to person and also on the biological and psychological characteristics of the person who is affected by them or is living or working in the vicinity of the HVTLs for a specified amount of time which is sufficient enough to have that person affected by it. Sometimes the radiations so emitted are strong enough to cause cellular degradation due to the damaged or altered DNA and that also depends on the time of exposure and voltage that is being transmitted by the overhead HVTLs the type of symptoms depends on the exposure to the radiations.

The effects of the electromagnetic radiations emitted by the overhead high voltage transmission line can't be left neglected because of the perilous outcomes which have been observed since the past few years. Due to the increase in growth of the population the demand for the electricity consumption is increasing in a hasty manner. The electromagnetic radiations emitted by the HVTL have various effects on the human body some which are long term and some are short term.

The short term effects depends on the smaller exposure time could cause health effects like

- Headache
- Dizziness
- Vomiting
- Irritation
- Fatigue
- Insomnia
- Lower motor and sensory functions in children

Relatively larger exposure time to the EMR can result in neurological disorders or some serious chronic health issues like cancer.

The long term and serious effects which are so observed can be divided into the type they affect like the one type would be neuropsychological and the other could be classified as to related with the body and its organ related health issue.

- Many of studies have shown that there are possible link between the EMF exposure and childhood leukemia as proposed by Choo& Chung, 2003.
- In case of adults, the chronic lymphatic leukemia shows weak evidence for the magnetic field exposure as reported by the national institute of environmental science (NIEHS) however in case of adults the proofs for the existence of the linkage between the brain cancer and between female breast cancers and EMF exposures are still found as proposed by Patty and Hill, 2006.

- Various tests have been done on animals as well as humans to prove the point that EMR leaves a great impact on the human body and those of which is headache, frequent irritability, fatigue, stress and nausea which continued for a longer period of time.
- Stunted growth is also a major concern which has been linked with the EMR and the exposure to it.
- More chances of having various types of cancer in adults and children.

Not only did the health effects which are visible or can be judged easily by looking but the radiations might decrease or alter the mineral content in the human body which could further cause problems if not treated at the required time and properly too.

In the neuropsychological disorder, the psychological behavior of the person affected is altered to some extent which may lead to many disorders which could be temporary and some could last a lifetime, depending on the amount of the exposure to the HVTL.

To study the effects of EMF generated due to overhead HVTLs on human beings certain experiments have been performed to prove the hypothesis that HVTL exerts a unignorably impact on the living beings especially humans. In some experiments which were performed on humans and animals, it has been found that the exposure to the EMF interferes in the growth rate in a depressing manner. Unfortunately, Due to the lack of certain consistent proofs and stable data the studies and analysis regarding the correct interpretation of the association between the health issues and the radiations makes it difficult and insufficient for supporting the effects so proposed.

Electroencephalography (EEG) is a test to electrical activity of the brain. An electroencephalogram (EEG) is an electro physical methodology accustomed realizes issues associated with electrical activity of the brain. An EEG follows and records brain wave patterns. Tiny metal discs with thin wires (electrodes) are placed a unit on the top, and then send signals to a laptop to record the results. Biorhythm could be a consistent vacillation of physical and mental conditions of an individual. From the time of birth, a variety of conditions reoccurs within the lifetime of an individual, depending on several influences. Triglycerides are the fat which is found in the human blood, impairment of the secretion of triglycerides is a factor in the accumulation of fat in the livers of essential fatty acid-deficient animals.

The tests conducted before and after to the prior exposure to the ELF on the rats gave the results that the rats which were trained to perform certain simple task were unable to do the task with as much efficiently as they were doing before being exposed to the ELF. Such experiments prove that the prolonged exposure to the EMF causes biological disorders in the exposed subjects. The effects of EMF on the people living near HVTLs can't be neglected, it has been proposed that the central nervous system is sensitive to the exposure of EMF or the elf and that could be due to the characters of the neuronal transmission. The behavioral effects can be measured or judged on the basis of response time and type accuracy.

In a test performed on two schools in the vicinity of HVTL, certain results were obtained which were indicating that the long term exposure of EMF leads to lower motor and sensory functions in children. Not only this by an eminent study done, it was indicated that the children living near the HVTL have a very high probability of getting blood cancer than that of those who don't.

Various methods for calculation of Electric Field:
Here, associate degree overhead transmission line, settled on a flat area is represented. Figure 4 shows a pylon of the overhead line and therefore the configuration of the conductors. There are various methods use for calculate the electric field. Here two methods have been included for doing the analysis of the same.

Analytical Approach
As purposed by Mr. J.R. Reitz and F.J. Milford below is the research equations and that states, each of the overhead HVTL near the earth can be considered as a line charge near a plane conductor. Using the image technique [12] the voltage $\varphi(\vec{x}, \vec{y})$ and the electrical field E(x, y) can be calculated. In Fig 4, an unload line charge (per unit length) has the image line charge (per unit length) –λ and the conducting plane (earth) coincides with the xz-plane. The voltage φ(x, y)due to the two infinitely long parallel line charges λ and -λ, as shown in Fig 4, can be written as [12],

Figure 4: Line charge and its image
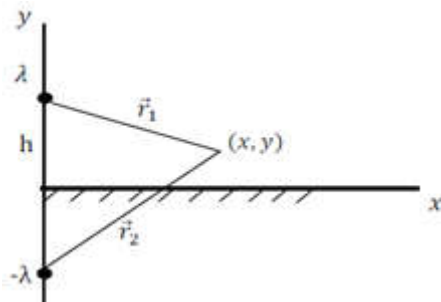
$$\varphi(\vec{x}, \vec{y}) = -2k\lambda \ln \frac{r_1(x,y)}{r_2(x,y)} \quad (2)$$

Where,

$$k = 1/(4\pi\varepsilon_0) = 9 \times 10^9 (Nm^2)/c^2$$
$$r_1(x,y) = \sqrt{(x^2 + (y-h)^2)}$$
$$r_2(x,y) = \sqrt{(x^2 + (y+h)^2)}$$

In the electrostatic case, the relation between E and $\vec{x}$ has the simple form as below [13]:

$$(\vec{E})(x,y) = -\vec{\nabla}\varphi(x,y) \quad (3)$$

In the Cartesian coordinate system, the x and y components of electrical field due to the unloaded single phase of overhead transmission line (Fig.4) can be written as;

$$E_x = -(\partial\varphi(x,y))/\partial x$$
$$= 2k\lambda$$
$$[x/(x^2+[(y-h)]^2)-x/(x^2+[(y+h)]^2)] \quad (4)$$
$$E_y = -(\partial\varphi(x,y))/\partial x$$
$$= 2k\lambda$$
$$[(y-h)/(x^2+[(y-h)]^2)-(y+h)/(x^2+[(y+h)]^2)] \quad (5)$$

Finally, according to the equations (4) and (5), we can calculate the electrical field strength as below,

$$E = \sqrt{([E_x]^2 + [E_y]^2)} = (8k\lambda h^2)/((h^2-2hy+x^2+y^2)(h^2+2hy+x^2+y^2)) \quad (6)$$

Here, in analytical method has been studied for the analysis of electric field due to the conductors on the human body standing beneath the HVTL.

Designing of electric fields around electric power transmission lines
As purposed by Chari, M.V.K. and Weiner the following equations and result has been obtained. Wave equation or Helmholtz's equation is used to show electric fields (**E**) radiating from a Transmission line as in Eq. (7) [14], [15] as per Faraday's law.

$$[\nabla]^2 E - \sigma\mu \, \partial E/\partial t - \varepsilon\mu \, (\partial^2 E)/(\partial t^2) = 0 \quad (7)$$

Here εis equal to the dielectric permittivity of medium, μ and σ equal to the magnetic permeability and the conductivity of conductors, respectively.

The time harmonic mode has been considered in this paper as system governor and electric field is represented in complex form,

$$\mathbf{E} = E e^{jwt}$$

Therefore,

$$\partial E/\partial t = j\omega E \text{ and } (\partial^2 E)/(\partial t^2) = -\omega^2 E \quad (8)$$

Here ω is known as angular frequency. From Eq. (7), is substituted by the complex electric field, Eq. (7) can be written as follows.

$$\nabla^2 E - j\omega\sigma\mu E + \omega^2 \varepsilon E = 0 \quad (9)$$

When considering the problem of two dimensions in Cartesian coordinate *(x, y)*, hence

$$\partial/(\partial x)(1/\mu \, \partial E/\partial X) + \partial/\partial y (1/\mu \, \partial E/\partial Y) - (j\omega\sigma - \omega^2 E)E = 0 \quad (10)$$

Analytically, no simple solution exists for the above equation. Consequently, in this paper the FEM is decided to be a potential apparatus for discovering estimated electric field solution for the equations described in Eq.(10) as described.

3. Result

In this paper we have observed that the negligence of the proper awareness about the effects of EMF could be hazardous. Although some of the results are still hypothesis but its adverse effects can't be ignored. And proper distance as prescribed should be maintained from the overhead HVTLs.

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