Review Paper:

Increased density of high electric voltage lines causing hazardous effect on plants

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Abstract

Environmental effect of power distribution lines includes loss of vegetation, loss of agricultural lands and altered human and animal activity. However, the hazardous effect of power lines on the individual growth, metabolism, yield and reproduction of plants has not been studied in detail. Current understanding confirms that the vicinity of power lines can alter plant life because of static electric field.

These effects include altered growth, burning of plant parts, altered biochemical parameters such as (i) Mechanical damage (ii) Altered growth (iii) Reduced seed germination (iv) Altered respiration parameters (v) Altered biochemical parameters such as changes in elemental concentration, enzymatic activity, chlorophyll content and phenol content (vi) Altered membrane functions and (vii) Altered cell cycle. However, the effect of proximity of power lines on the most significant molecular parameters such as DNA replication, transcription and translation and DNA repair activity has not been studied.

Keywords: Biochemical parameters, Electrotropism, Electricity and Plants, High Voltage Direct Current lines, Static Electric Field.

Introduction

Delivery of electricity has always been associated with environmental issues like loss of forest, agricultural fields, human settlements, biodiversity along with the effect on individual life under these power lines[4,10]. Static electric fields have a steady intensity and direction across time. Such electric fields occur due to high tension electric lines, subway and railway electric lines, tram lines. Compared to magnetic fields, static electric fields do not penetrate the biological body.

In such cases, electric field persists on the periphery of living systems and the intensity depends on the distance from the power lines[5,24].

The strength of the electric field is location dependent. The magnitude is negatively correlated to the distance from the power lines. A living organism under a high electric line is exposed to the static electric field. Based on this logical reason, there has been an increased awareness and concern on human health among the public regarding high voltage electric lines and extra high voltage electric lines[2].

With the development of ultra-high-voltage direct-current transmission, the intensity of static electric field under transmission lines increased, increasing public attention on its potential health effects[14]. There have been several discussions on the disastrous effects of static electric field on animals[8,24]. However, the impact of such an electric field on plants has been less understood. The current review provides recent up-to-date data on the disastrous effect of the static electric field.

Plants under Extra High Tension Voltage lines –AC: 66 kV, 110 kV, 220 kV, 400 kV and 700 kV are the most common voltages in high tension electric lines for AC. One of the direct impacts of these lines is because of the land used for the construction of towers. Generally, these lines pass through forest lands and agricultural fields and affect the growth of the vegetation and forests[6,7,13].

Experimental studies conducted in seedlings of gymnosperms *Cupressocyparis leylandii* revealed a negative relationship between the diameter as well as specific leaf area and distance away from the electrical line[7]. This study experimentally proved a significant relationship between the proximity of a power line affecting the growth of plants. Another experimental study showed that there is a positive correlation between the pod numbers and its propinquity to 132 kV power lines in cultivated mustards. However, the presence of power lines induces an altered metabolic profile as evidenced in the biochemical and antioxidant parameter evaluations in mustard leaf (*Brassica chinensis*)[17].

The effects of electromagnetic field with contiguity of 33 kV and 275 kV electric transmission lines exhibited an enhanced level of protein, chlorophyll pigments, soluble nitrogen and peroxidase activity at a distance of 20 meters from power lines[17]. According to Raghu et al[25], the proximity of high voltage lines exhibited a reduced growth rate and biomass. Such reduced or altered physiological parameters indicate a lower rate of cell division and altered cell enlargement. Such responses can be related to reduced activity of hormones.

Altered peroxidase and chlorophyll content has been correlated to the stress faced by plants[28,31]. Such altered metabolic profiles can be an indication of DNA damage or mutation. This points out the significance of studying the

relationship between high voltage lines and DNA damage. Further, it is also required to confirm whether it is a short term effect or long term persistent effect. It has been already proved that an electromagnetic field induced DNA breaks in cultured animal cells[18]. There are also few reports on the positive correlation between the distance from the line and growth as well as pod length[3].

High Voltage Direct Current Lines: Massive renewable energy integration and passive network power supply have recently gained a lot of attraction. This fact along with technological feasibility has increased HVDC lines and increased demand over conventional HVAC lines[1,14]. HVDC lines are potential sources of the static electric field. They will not penetrate the living body, instead will remain confined to the periphery[26,34]. The electric field and ion current environment under HVDC transmission lines are important design considerations and the static electric field under HVDC lines is up to 35 kV/m[16].

The effect of electric field on plants was conducted by the pioneering works of Murr[19-23] at The Pennsylvania State University during the years 1963-1966. According to the researchers, plants respond to the electric field. This is known as electrotropism. Electrotropism can sometimes be stimulative but can also be destructive or sometimes lethal. Murr and his team conducted experiments on diverse plants such as orchard grass, sorghum, bush bean, sweet corn and wax bean. They recorded some of the hazardous effects such as reduced plant growth, physical damage of the leaf tips and altered essential element distribution patterns. They also found that these effects depend on the electric field's strength and will have a threshold limit.

In a pioneering study, dry morning glory seeds were subjected to the electric field and the effects were analysed using NMR spectroscopy. The results exhibited swelling of macromolecules which led to the membrane system disruptions. These experiments confirmed that one of the immediate effects of electric polarization is membrane damage. This can lead to excess water accumulation and hydration of macromolecules which are stored in cells[11]. This study was conducted with a varying electric field strength ranging from 133 kV/m to 500 kV/m with a duration of 5 to 60 minutes.

In another study involving seeds of *Pisum sativum*, a significant increase in the growth of stem and roots is observed. In this case, the treatment was done for 8 minutes[15]. An increased growth does not mean that plant quality is improving and hence cannot be considered beneficial for yield. Klink et al[12] conducted experiments on an aquatic plant *Elodea canadensis* and concluded electrotropism response in growth and altered trace metal content. Rice seedlings exhibited altered superoxide dismutase, peroxidase and catalase activities along with enhanced permeability for enzymes[32].

Table 1
Hazardous effect of power distribution lines on plants

S.N.	Nature of Hazardous effect
	Mechanical damage
1	Damage of leaf tips[19,23]
2	Burning of leaf tips > 80 kV/m[20]
3	Damage on cell structures[21]
	Altered growth
4	Loss of growth rate[23]
5	Gain of growth rate[12,15]
	negative relationship of growth parameters and distance from the line[7]
	Reduced seed germination
6	Exposure to positive field resulted in loss of germination rate[29]
	Altered respiration profile
7	Affected peak respiration rate by delaying it[33]
8	Rate of respiration was affected[30]
	Altered Biochemical Parameters
9	Altered elemental concentration[12,22,23]
10	Altered enzymatic profiles[17,33,35]
11	Change in chlorophyll content[17]
12	Enhanced phenol[9]
	Altered membrane functions
13	Disruption of membrane systems[11]
	Altered cell cycle
14	Changes in cell cycle and cell division[27]

Conclusion

The power transmission lines are vital to our progress. These lines affect the individual plant life in multiple ways such as mechanical damage, changes in growth rate, elemental accumulation in cells, changes in chlorophyll parameters and enzymatic activity changes. However, the direct effect of power lines on flowering and yield as well as quality on crops has not yet been studied.

We highly recommend analysis on the effect of proximity of the power lines on molecular parameters such as DNA replication, transcription, translation and repair. The data generated in this regard will be highly beneficial in the effective planning of power distribution lines with low environmental impact.

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