International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-2 Issue-3, July 2013

Effect of High Voltage on the Resistance of Aloe Vera Leaves

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Abstract*—Every plant has a property to react to internal as well as external stimuli. There are many electromagnetic radiations present in environment to which plants react such as electrical fields, magnetic fields, and electromagnetic (EM) fields. A large number of products and applications in our day to day life make use of various forms of electromagnetic energy. One such form of energy is high voltage and high frequencies EM waves. High voltage means electrical energy at voltages which is sufficient to cause harm or death upon living things. The electromagnetic field from high power transmission lines affects the growth of plants. The growth and health status of plants can be accessed from the electrical properties such as resistance or impedance of its leaves. In this paper, the effect of high voltage on Aloe Vera leaves has been reported. Aloe Vera plant is chosen due to its various properties and uses in dermatology. Investigations were carried out to study the effect of high voltage on the resistance of the Aloe Vera leaves. The analysis of the results showed considerable amount of change in the resistance of the leaves due to high voltage and high frequencies.

***Index Terms*— Aloe Vera, D.C. resistance, high voltage, Tesla coil.**

I. Introduction

Modern civilization depends heavily on the widespread use of high voltage transmission lines for industrial, agricultural, and domestic purposes. This has enhanced the exposure to electromagnetic fields. It is well known that these electromagnetic fields have adverse biological effects on living organisms. Plants play an important role in the living world as main producers of food and oxygen; therefore, it would be beneficial to examine their relations with today's increased exposure to electromagnetic fields. The effect of high voltage causes alteration in electrical properties of plants. The plants have cellular receptors which are used to observe changes in their surroundings. These changes are of different types and vary from plant to plant. All living organisms generate and conduct electrochemical impulses all the way through their different tissues and organs. Properties of temperature sensing in plants has been demonstrated experimentally [1]. The High voltage means electrical energy at voltages which is sufficient to cause harm or death upon living things. High voltage is used in several applications like electric power distribution, cathode ray tube to generate X-rays, particle beams, vacuum tubes, manufacturing, and scientific applications [2]. Most of the areas in agricultural and forest lands are situated in the area where high power transmission lines pass. The voltage level of high power transmission lines are 400 KV, 230 KV, 110 KV, 66 KV, etc. The electromagnetic field from high power transmission lines affects the growth of plants. Extensive biological, geological, and oceanographic research has been carried out to investigate the effects of high voltage fields on the environment [3] [4]. In electrical power transmission engineering high voltage is usually considered any voltage above 35 KV. The voltage of these magnitudes can affect the plant in one way or the other as the most vital physical signal in any organism is electrical signal. In comparison to chemical signals (e.g. hormones) the electrical signal is able of transmitting signals more rapidly over long distances. Recently, biologists have revealed that electrical signals are significant in many physiological activities [5]. Gurovich and Hermosilla [6] studied the electrical signalling in fruit trees in response to water and darkness conditions. Desrosiers and Bandurski [7] investigated the effect of longitudinally applied voltage on the growth of Zea Mays seedlings. In plants, the basic modes of information transmission are the intracellular electrical signals. Electrical signals are involved in many processes in plants life including respiration, water uptake, and leaves movements [8]. Various changes regarding the growth (effect on the meristem), cell differentiation, shoot length, root length, leaf area, specific leaf weight, total biomass content, total water content, chlorophyll, carotenoide, soluble sugar, soluble starch, soluble protein content, biochemical, and antioxidant system has been shown to be affected by environmental electric and magnetic fields. The electric field treatment has also been found applicable as a minimally invasive method for processing of plant tissues, allowing and avoiding many undesirable changes in products, pigments, vitamins, and flavouring agents, which are typical for other pre-treatment techniques, including thermal, chemical, and enzymatic ones. Electric field treatment is also capable of microbial inactivation [9]. As the resistance of the plant tissues varies considerably from plant to plant, hence, a clear idea of plant tissue electrical properties is essential for the assessment of its health status. The effect of high voltage at high frequencies may be more significant as compared to low frequency fields.

Revised Manuscript Received on 30 July 2013.
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The objective of this paper is to investigate the effect of high voltage at high frequencies on the resistance of Aloe Vera leaves. The details of Aloe Vera are presented in Section II. The methodology is described in Section III. Results and discussions are discussed in Section IV and conclusions are presented in Section V.

II. ALOE VERA

The name Aloe Vera derives from the Arabic word "Alloeh" meaning "shining bitter substance" while "Vera" in Latin means "true". The botanical name of Aloe Vera is *Aloe Barbadensis Miller*. Aloe Vera has thick, green leaf like structures that grow from a central point. The leaves of this plant have no stem and are greenish in colour. Some varieties of Aloe Vera show white flecks on the upper and lower stem surfaces [10]. As far as the root of the plant is not damaged it can survive from temperatures ranging from 104° F down to freezing temperatures [11]. Mature Aloe Vera grows as tall as two and a half inches to four feet, with the usual plant being around 28-36 inches in length. Aloe Vera plant has been known and used for centuries for its health, beauty, medicinal, and skin care properties. It contains over 200 active components which includes vitamins, minerals, amino acids, enzymes, polysaccharide, and fatty acids. The bulk of the Aloe Vera leaf is filled with a clear gel-like substance, which contains approximately 99% water. This unattractive but highly beneficial plant has been used by different cultures since ancient times for its various benefits. The original industrial use of the plant was to grow for the production of a latex substance called aloin, which is yellow in colour possessing bitter and lingering taste. The plant latex contains the laxative anthraquinones that is shown to possess important antimicrobial activity against a broad variety of micro organisms [12]. Recently, Aloe Vera gel has been used as a lively component in several skin lotions, sun blocks as well as cosmetics [13]. The inner leaf lining of the plant is often used as a natural laxative. Dried latex from the inner lining of the leaf has traditionally been used as an oral laxative [14]. The inner portion of the Aloe Vera leaf contains a colourless and transparent gel. This transparent gel from the pulp of the fleshy leaves of Aloe Vera has been used topically for thousands of years to treat skin infections, wounds, burns and various other dermatologic conditions. Fig. 1 shows top view of Aloe Vera plant.

Fig. 1 Aloe Vera plant.

A. Distribution of Aloe Vera

Aloe Vera is a perennial, succulent plant with fleshy leaves. The natural range of *Aloe Vera* is unclear, as it has been widely cultivated throughout the world. [10]. It is widespread and can be found growing all the way through America, Africa, Europe, the Middle East, China, India, Pakistan and Australia. The plant is also distributed all through the India. In India in the hot dry valley of northwestern Himalaya it has become entirely naturalized. For its proper growth it needs a habitat which provides direct sunrays and well-drained soil. Aloe Vera has been widely grown as an ornamental plant. When these plants are grown in the open, they need the warmth of sunrays and defense from the cool weather because the plant consists of 95% water. Aloe Vera has been utilized in folk remedies from ancient times. Fig. 2 shows plantation of Aloe Vera for commercial use [15].

Fig. 2 Plantation of Aloe Vera for commercial use.

B. Aloe Flower

The Aloe flowers (Fig. 3) are yellow, tubular, and up to 3 cm long, with anthers and stigma protruding. The flowers are borne in cylindrical racemes on a branched panicle up to 90 cm tall.

Fig. 3 Aloe flower.

C. Aloe Vera Gel

It is the inner fleshy layer of Aloe Vera leaf. It is clear, colourless, and tasteless. This gel contains more than 90% of water and the rest is made of amino acids, lipids, sterols, and vitamins [16]. This gel contains more than 200 different substances. Chief among these are polysaccharides, glycol proteins, vitamins, mineral and enzymes. In Arabian medicine, the fresh Aloe Vera gel is used on the forehead as a remedy for headache or it is rubbed on the body to cool it in case of fever. It is also used as a disinfectant and laxative. In recent times, Aloe Vera gel has been used as an active ingredient in hundreds of skin lotions, sun blocks and cosmetics [11].

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Aloe Vera gel, like most natural juices in both fruits and vegetables, is unstable and subject to discoloration and spoilage from contamination by microorganisms. Fig. 4 shows Aloe Vera gel coming out of a leaf.

Fig. 4 Aloe Vera gel.

III. METHODOLOGY

The investigations were carried out on the leaves of Aloe Vera plants to study the effect of high voltage on the electrical resistance of the leaves. The plants were grown in earthen pots containing fertile soil under natural environmental conditions. In this research, high voltage setup was installed and the high
voltage of around 50 KV at 1 MHz using Tesla coil was applied on the Aloe Vera leaf to investigate the changes in the resistance of the leaves. The experimental setup is shown in Fig. 5.

Fig. 5 High voltage setup for exposure of Aloe Vera plants.

The voltages as well as currents across the leaves were measured and corresponding resistances were calculated. High voltage of 50 KV was generated with the help of Tesla coil and the plants were placed surrounding the coil at specific distances. Tesla coil is an electrical resonant transformer which is used to produce high voltage low current, high frequency alternating current electricity. It is essentially a high frequency air core transformer. Tesla coil can produce comparatively higher voltages than other artificial sources of high-voltage discharges or electrostatic machines. Tesla coil is different from conventional transformer in a fact that Tesla coil's windings are loosely coupled with a large air gap. Two different Aloe Vera plants were taken and three leaves from each plant were selected. These Aloe Vera plants were kept at different distances from the Tesla coil. Now the first plant bearing three leaves was kept at a distance of 15 cm from the Tesla coil. The first leaf of this plant was at a distance of 10 cm, second leaf at a distance of 12 cm and third one at 15 cm. Similarly second Aloe Vera plant was kept at a distance of 50 cms from the Tesla coil. The leaf distances were 30 cm, 45 cm, and 50 cm respectively. So a total of six leaves were taken to study the effect of the high voltages. On each of the leaf surface two electrodes were attached at a distance of 6.5 cm. Extra care was taken to ensure that the plant tissues are not damaged while connecting the electrodes to the leaf. The set up for resistance measurement is shown in Fig. 6. The Aloe Vera leaves were exposed to high voltage of 50 KV for different time intervals of 1 h, 3 h, 18 h, and 24 h.

Fig. 6 Setup to calculate resistance of the Aloe Vera leaf.

IV. RESULTS AND DISCUSSIONS

Investigations were carried out using high voltage at high frequencies (1 MHz) for the determination of the changes in the resistance of the Aloe Vera leaves. Aloe Vera tissue acts as an ionic conductor and when the direct current is passed through an ionized solution the well known phenomenon of polarization occurs. Aloe Vera leaves were given high voltage exposure of order 50 KV for different time intervals of 1 h, 3 h, 18 h, and 24 h. The corresponding values of the resistances before and after the exposure were calculated. The resistance of leaves without exposure to high voltage was measured at a distance of 10 cm, 12 cm, 15 cm, 30 cm, 45 cm, and 50 cm and were found as 0.31, 3.0 MΩ, 0.71 MΩ, 0.85 MΩ, 1.60 MΩ, and 0.80 MΩ, respectively. It was seen that on exposure to high voltage, the resistance of the Aloe Vera leaves got decreased. Table I shows the resistance of the Aloe Vera leaves before and after exposure to high voltage at different time intervals of 1 h, 3 h, 18 h, and 24 h.

After exposure to high voltage the value of resistances started decreasing with time. For example, after 1 h the value of leaf resistance at a distance of 10 cm was found as 0.29 MΩ and at the end of 24 h the value reached to 0.26 MΩ. Almost same trend was observed at distances 12 cm, 15 cm, 30 cm, 45 cm, and 50 cm for other leaves. These results are plotted in as histogram in Fig. 7.

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V. CONCLUSION

Investigations were carried out to study the effect of high voltage on the resistance of the Aloe Vera leaves. The Aloe Vera leaves were exposed to high voltage field. The analysis of the results showed that the on exposure to high voltage the resistance of the Aloe Vera leaf got decreased with the increase in time. This is because on exposure to high voltage the current across the Aloe Vera leaf starts increasing due to ionization which in turn decreases the resistance of the leaf. Hence high voltage alters the electrical properties of the Aloe Vera plant. These results may be useful for researchers to evaluate the effects of high voltage on medicinal properties of Aloe Vera plants. More ever, the investigations may be exceptionally important for the evaluation of the health of the Aloe Vera to improve the quality of the products derived from these plants.

Table I. Resistance of Aloe Vera leaves calculated before and after exposure to high voltages.

Distance (cm)	Resistance before exposure (MΩ)	Resistance after exposure (MΩ)			
		1 h	3 h	18 h	24 h
10	0.31	0.29	0.28	0.26	0.26
12	3.00	2.41	2.20	2.20	1.75
15	0.71	0.19	0.16	0.14	0.13
30	0.85	0.76	0.74	0.80	0.78
45	1.60	0.89	0.61	0.57	0.47
50	0.80	0.62	0.68	0.67	0.66

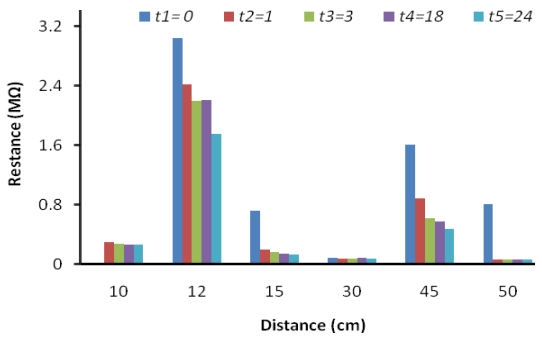

Fig. 7 Variation of resistance of Aloe Vera leaves at different time intervals.

Here, $t1 = 0$ corresponds to the value of resistance before the high voltage exposure and $t2$, $t3$, $t4$, and $t5$ corresponds to the value after 1 h, 3 h, 18 h and 24 h, respectively.

ACKNOWLEDGMENT

The authors would like to express a deep sense of gratitude and thanks to Mr. Jang Bahadur Singh, Ph.D. research scholar, Deptt. of Physics and Electronics, University of Jammu, Jammu, for extending his knowledge and help in establishing the experimental setup and conducting the investigations. The authors would also like to express sincere gratitude and appreciation to Mr. Atif Hussain Waza for his technical support and valuable ideas.

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