

Micronutrients Behaviour in Botanic Habitats As Affected by High Voltage-Electromagnetic Field

Fatima M. Z. Alaish¹, Hassan S. M. Al-Zahrani¹, Samir, S. El-Solaimani², Sherif S. Z. Hindi^{2*}

Department of Biology, Faculty of Science, King Abdullaziz University, Jeddah, Saudi Arabia¹

Department of Arid Land Agriculture, Faculty of Meteorology, Environment and Arid Land Agriculture

King Abdullaziz University, Jeddah, Saudi Arabia²

ABSTRACT: *Calotropis proceragrown* near high voltage-transmission electricity towers was selected to investigate the effect of electromagnetic field (EMF) on micro-nutrient content in leaves. Sampling was performed at four different high voltage- towers built in different years (1981, 1991, 2008, and 2013). Three sites were selected apart from each tower (0 m, 50 m and 100 m) beside the control site independent from the EMF effect. All soils are slightly alkaline and none saline. Soil texture for all sites were sandy except in 1981 tower site whereby the texture was sandy loam. The highest electrical conductivity value was recorded at Tower 2008 at 100 m which is 2.526 mS/cm, while the lowest value was recorded at tower 2008 at (0) distance which is 0.307 mS/cm. For the elemental content in leaves, the interaction effect of establishing time of towers and distance was affected each of the micronutrients (Fe, Mn and Zn), the heavy metals (Ba, Pb, V, Al and Ga), while each of Cu, Ti, Cr and Ni were not significantly affected. All investigated sites under the effect of electromagnetic field showed no considerable variations compared to the control.

KEYWORDS: Electromagnetic field, High voltage-transmission lines, *Calotropisprocera*, Micronutrients.

I. INTRODUCTION

The Kingdom of Saudi Arabia comprises an area of 2.25 million km², encompassing vast deserts, rugged mountains, coastal cities, villages, and settlements. The country is the fastest growing electricity consumer in the Middle East. Electricity consumption in Saudi Arabia was increased sharply during the 1990–2010 period due to rapid economic development, the total amount of energy produced by the Saudi Electricity Company in 2013, is about 198,900 GWH [1]. Capacity is planned to be increased up to 120 GW by 2020. Electricity generated from power plants is usually sent over long distance through overhead power transmission lines. These power transmission lines are high-voltage wires that run along large towers and form an interconnected grid that brings power from power plants to local substations around the country via a network of high-voltage electricity. The voltage existing between each wire transmission tower is 380kV, all towers height is between 65-75 meters and there are 24 conductors in each face in the tower [1].

Severe wind erosion and moving sand are two main factors affecting the indigenous soil that are induced by the effect of transmission lines. For plant nutrients content, it has been reported that external electromagnetic field (EMF) influence both the activation of ions and polarization of dipoles in living cells [2,3,4]. They showed that alternating magnetic field had a significant effect on the nutrient element composition of leaves in strawberry plant (*Fragariaananassa*). For strawberry, the concentrations of N, K, Ca, Mg, Fe, Mn and Zn in leaves were significantly increased and those of P and S were significantly decreased, but Cu and Na were not significantly affected by the EMF treatments [2,3,4]. In a study conducted by Duarte Diaz *et al.* [5], he found that EMF had a positive effect on nutrient uptake.

In addition, a study on tomato plants revealed that application of EMF to irrigation water increased plant nutrient contents of plants [5]. The magnetic field may play an important role in cation uptake capacity and has a positive effect on immobile plant nutrient uptake [4]. Therefore, EMF could be a substitution of chemical additives, which can reduce toxins in raw materials and thus can raise the food safety. Pakhmová [6] and Dhawiet *al.* [7] found that concentrations

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

of Ca, Mg, Mn, Fe, Na, K, and Zn increased in palm leaves when the seedlings were exposed to different magnetic fields for different periods: 0, 30, 60, 180, 240 and 360 min., while P concentration decreased with rising of EMF intensities and durations of exposure. Static magnetic field has a potential to enhance growth due to the positive effect on the plant major elements such as Ca and Mg, but negative electrical charges on the plants inhibited the uptake of anions such as P [8].

Moreover, Hanafy et al. [9] found that the elements concentration in the exposed wheat grains showed a higher decrease in K element as a result of outflow of K which may be occurred as a result of destruction of plasma membrane. Because of the high field strength, ions in the soil could potentially migrate. Freeman et al. [10] investigated the EMF on soil nutrients content under soybeans grown at 50-m and 100-m distances from a high-voltage power line (675 kV). Their results showed that neither the pH nor the concentration of any of the sampled elements (Ca, Cu, Fe, K, Mg, Mo, Na, Pb, Se, or Zn) differed with distance from the transmission line. On the other hand, magnetized water was shown to have three main effects: increasing the leaching of excess soluble salts, lowering soil alkalinity and dissolving slightly soluble salts such as carbonates, phosphates and sulphates.

However, the degree of effectiveness of magnetized water on soil salinity and ionic balance in soil solution depended greatly on the traveling distance of magnetized water along the drip irrigation lines [11]. Tai et al. [12] observed that on subjecting water to magnetic field, leads to modification of its properties, as it becomes more energetic and more able to flow which can be considered as a birth of new science called magneto biology. They also pointed out that magnetized water prevents harmful metals such as lead and nickel, up taken by roots and reaching fruits and roots. However, it increases the percentage of nutrient elements like phosphorus, potassium and zinc. Some researchers have reported that magnetic treatment affects water properties such as light absorbance, pH, and surface tension [13,14]. However, these effects have not always been confirmed [15]. Amiri and Dadkhah [16] found that changes in surface tension due to magnetic treatment can be a key point in tracing impurities in water. Furthermore, Johnson and Guy [17] and Moon and Chung [3] have reported that external electric and magnetic fields influence activation of ions in living cells.

Esitken and Turan [4] investigated the effect of alternating magnetic field effect on plant nutrient composition. They reported that MF had a significant effect on the nutrient element composition of Strawberry (*Fragaria ananassa*) leaves. They also observed that N, K, Ca, Mg, Fe, Mn and Zn, in leaves were significantly affected by MF treatments. In the present study all elements were high at (0 and 50 m) distance apart from the source. On the other hand, micronutrient results indicated that Cu, Fe, Mn, Zn, were high in '0' m distance at all towers age that is in consistent with the results of [4]. It is well known that Fe is required by plant in small amounts to be involved in many important compounds and physiological processes such as in chloroplast and some protein formations [18,19].

When analysing the results of the toxic elements in plants in terms of Ba, Pb, Ti and V, it was noticeable that fortunately Barium and Lead are found in trace amounts. However, titanium and vanadium are high especially in case of titanium. The role of titanium in plants metabolism is not truly clear. Some authors indicated that Ti enhanced the growth of leaves for some plants and is mainly accumulates in assimilation organs and hence may intensify plant growth and development increasing intensity at green colour (higher chlorophyll content), as was reported by Tlustos *et al.* [20]. This can also explain the high chlorophyll content in *Calotropis procera* in the present study.

Concerning vanadium, it has a role in plant nutrition and it was found to be toxic in many plants and retards the growth of tomato plants when 40mg/L [7] exceeded. However, *Calotropis procera* was not affected in the present study by the high quantity of V mainly, because of the presence of the latex which makes protection to the leaves [21]. Results of elements in soil showed higher amounts of macro elements at all distances and tower ages compared to plants. Surprisingly, the toxic elements in terms of Barium, Lead, Titanium and V indicating that *Calotropis procera* is a good phytoremediator to the soil.

Freeman *et al.* [22] investigated the effect of EMF on soil elements and confirmed that neither pH nor concentration of Ca, Cu, Fe, K, Mg, Mo, Pb or Zn differed with distance from the source.

Objectives

Studying the effect of electromagnetic field induced by high voltage-electromagnetic field [23,24,25,26,27] on accumulation of elemental content of plant leaves as well as on soil ions status and some other properties.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

II. MATERIALS AND METHODS

The Study Area and Towers Selection

To evaluate the effect of electromagnetic field (EMF) on the nutrient content of wild plants grown around or near the electricity towers, a field study was conducted at North Jeddah city during 2013-2014. A number of plant species found in the study areas, but *Calotropis procera* L. was selected as a common plant for this study. Sampling was performed from four different towers for electricity high-pressure transmission lines built at different years (1981, 1991, 2008, and 2013). Three sites have been selected from the tower, starting from beneath the tower (zero m), 50 m and 100 m apart from tower centre. A control site was also chosen far from electricity towers and lines effects.

Magnetic field intensity (MFI)

Trifield Range Broad Band, having frequency range of (0-100) milligauss was used to measure the magnetic field in the sampling sites, as was shown in Table 3.

Light Intensity

Quantitherm Light meter ($\mu\text{mol}/\text{m}^2\text{s}^{-1}$), Thermometer ($^{\circ}\text{C}$) was used to measure the light intensity at the sampling sites, as was shown in Table 4.

Plant Sample Collection Preparation

Five fresh leaves of *Calotropis procera* were collected from one shrub in each distance of the five investigated sites. The collected *Calotropis procera* [28] leaves (5 leaves) were thoroughly washed and rinsed with distilled water. The samples were then dried in oven at 75°C for 48 hours until a constant weight. The dried samples were then ground into fine powder and stored in fresh plastic polythene bags ready for further use.

Location of Sampling:

Composite and homogenized soil samples at a depth of 0-30 cm were taken from a distance of 0.0 m, 50 m and 100 m in the four investigated areas and one sample from the reference (control) area which was not affected by the electromagnetic field.

Soil Sampling

At sampling sites, 15 soil samples were taken to a depth of 30 cm. Steel auger (5cm diameter) was used. Soil samples were combined and the resulting composite sample weighed approximately 500 g. The samples were placed in clear polythene bags, which were clearly labelled and delivered to the King Abdulaziz University soil lab for further analysis.

Reagent and Solutions

All solutions used in this study were prepared from analytical reagent grade chemicals. Nitric acid, hydrochloric acid and hydrogen peroxide were obtained from certified commercial companies in Saudi Arabia. The standard solutions of analysis for calibration procedure were produced by diluting a stock solution of 1000 parts per million (ppm) of all the investigated elements.

Preparing of Plant Samples:

Major and minor nutrients in the plant have been measured after the digestion of plant samples have been digested severally by drying the samples aerobically and cleaning them. The next steps was grinding them until they became in the form of a homogeneous powder, next was taking a known weight of this powder (0.2g), placing it in the digestive tube and add a known amount of pure and concentrated sulfuric acid (1ml). The test tubes were then placed on the heater inside the gas cabin and increase temperature gradually (15-30 minutes) until the sample becomes black and homogeneous. Cooling the test tubes came next and added (1ml) of an equal mixture of the concentrated sulfuric acid and per chloric acid (1:1).

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

After complete heating (20-30 minutes), the mixture turns into a colorless liquid then complete the size to (100 ml) of pure distilled water according to the method of Humphris [29] and Stewart [30] and then takes 5 ml of each sample and adds several ready reagents of the reagents of phosphorus. Then measure an estimate of the major and minor nutrients in this extract by using measuring atomic absorption device. (Atomic absorption spectrometer model, varianSpectr AA 10/Perk In Elmer Spectr AA 3100/ Mettler DL55/ HACH DR2010/WTW).

Determination of Ion Content

Micro elements; Cu, Fe, Mn and Zn; Heavy (toxic) elements; Ba, Pb, Ti, V, Cr, Ga, Ni and Al were measured. The sample digests were analyzed in three replicates for nutrients and heavy metals content by Optical Emission Spectrometer–Optima 8000 by Perkin Elmer (ICP), to enable fast and accurate measurements was used.

Preparation of Soil Samples:

Composite and homogenized soil samples at a depth of 0-30 cm were taken from a distance of 0 m, 50 m and 100 m in the four investigated areas and one sample from the reference (control) area which was not affected by the electromagnetic field. All 15 soil samples were air-dried at ambient temperature. Soil samples were sieved to remove stones and plant debris, and mixed thoroughly to obtain a representative sample. Soil samples were rolled manually with a steel roller and then sieved through a mechanically vibrating 2-mm stainless steel mesh. Both devices were cleaned after each sample had been processed to avoid cross-contamination.

Preparation of Soil Extract:

Soil extract was prepared by mixing soil and distilled water (1:5). 50 g of soil for each sample was mixed with 150ml and put for two hours in the Electric shaker. The mixture was filtered and the volume was completed to 250 ml and used for detection of element content in the soil.

Soil Texture

The soil texture was determined by sieve analysis method. 100 g soil from each sample was add into sieve and allowed to shake in electrical Shaker (Model SAKER BATH-ORBIT) for 10 minutes. The particles size of sand silt and clay was classified according to their size as follows:

Sand= (2.0 mm to .05 mm); Silt = (.05 mm to .002 mm); Clay = (<.002 mm)

Following American Standard Measurement, the weight of the soil was taken by a digital balance and the % of constituents. The soil granules (sand, silt and clay) were calculated based on their fraction of the original sample mass as follows:

Sand % = (oven dry sand mass/original sample mass) x100

Silt % = (oven dry silt mass/original sample mass) x100

The clay % is determined by calculating the difference of 100%, minus the sum of the Sand% and Silt%, Clay% = 100 - (Sand% Silt %).

Soil pH

Soil pH was determined for all samples by mixing 50 g of soil sample with 50ml distilled water (1:1). After 10 minutes, pH was determined using a digital pH meter (pH meter, WTW model 512) with a glass electrode. Each suspension was stirred vigorously using a glass rod immediately prior to pH determination. The procedure was described by McLean [31].

Soil Electrical Conductivity (EC)

Soil electrical conductivity was measured by using electrical conductivity meter (EC-meter, Mattler MC226, Taledo) and expressed in mmohs/cm at 25co in 1:5 soil water extract sample as described by Black [32] and Jackson [33].

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

Soil Soluble Ions

Micro-nutrients, namely Cu, Fe, Mn and Zn and heavy (toxic) elements, namely Ba, Pb, Ti, V, Cr, Ga, Ni and Al were measured in the soil extract prepared above. The samples were analyzed for elemental analysis by Optical Emission Spectrometer–Optima 8000 by Perkin Elmor (ICP).

Statistical Design and Data Analysis

Statistical analysis of all plant leaf attributes along with heavy metals and micro-nutrients data were performed separately to confirm the dissimilarities and integrity of results through applying Fishers analysis of variance technique (Steel and Torri, 1997). Least significant difference LSD test $P \leq 0.05$ using SAS 6 were applied for comparing treatments means. Graphical representation of the data was constructed through MS excel.

III. RESULTS

Effect of Electromagnetic Field on pH, Electrical Conductivity and Texture of Soil

Table 1 shows the data on soil pH, electrical conductivity and soil texture. All investigated sites under the effect of electromagnetic field showed no considerable variations compared to the control. All soils are slightly alkaline in pH and none saline. Soil texture for all sites were sandy except in 1981 tower site, where the texture was sandy loam. The highest electrical conductivity (EC) value was recorded at Tower 2008 at (100 m) which is (2.526 mS/cm); the lowest EC was recorded at tower 2008 at (0) distance which is (0.307 mS/cm).

Table 1: Effect of electromagnetic field on soil pH, electrical conductivity and texture.

Tower age	Distance (m)	pH	EC mmhos	Soil particles distribution%			Texture
				Sand	Silt	Clay	
1981	0	7.67	0.568	55	39	6	Sandy Loam
	50	7.36	1.4	52	39	9	Sandy Loam
	100	7.45	2.482	53	39	8	Sandy Loam
1991	0	7.56	0.955	86	9	5	Sand
	50	7.34	1.278	92	5	3	Sand
	100	7.27	1.416	88	7	5	Sand
2008	0	7.86	0.307	91	5	4	Sand
	50	7.78	0.803	87	11	2	Sand
	100	7.72	2.526	79	16	5	Sand
2013	0	7.29	1.427	91	5	4	Sand
	50	7.37	1.387	91	6	3	Sand
	100	7.45	0.903	88	4	8	Sand
Control		7.44	0.962	89	8	3	Sand

Micro-nutrients:

For the micro-contents in leaves, it is clear from Table 2 that Fe, Mn and Zn were affected significantly by the interaction effect of establishing time of towers and distances, while Cu was not significantly affected. The highest content of Fe was observed for tower 2013 at (0) distance (363.4 mg/kg DW) and minimum content was observed for tower 1991 at 100 m (182.33 mg/kg DW). The highest content of Mn (49.2 mg/kg/DW) was observed for the tower 1981 at (0) distance and the minimum (18.96 mg/kg DW) was observed for tower 2013 at (100 m). The highest content of Zn was observed in the control plant (15.26 mg/kg DW) and the minimum content was observed under tower 1991 at (0) distance (0.3 mg/kg DW). It is noticeable that Fe is the highest element among other elements in all the investigated sites.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

For Cu and Zn contents of soil at all towers, except for tower 2013 and the control at all distances, it was noticeable that their amounts can be considered as traces in soil, and a little bit increase in Zn was obtained (Table 2). In addition, the content of Cu didn't affected significantly, whereas the Zn was significantly affected at $p \leq 0.01$. In addition, the content of Zn was increased linearly in all investigated sites with increase of the distance.

Table 2: Means of micronutrient concentrations (mg/kg DW plant) in investigated plants as affected by the combined locations and its distances.

Treatments	mg/ kg in leaves				mg/ kg in soil		
	Cu	Fe	Mn	Zn	Cu	Zn	
1981	0	1.63	242.73	49.20	0.16	0.027	0.000
	50	1.70	227.06	36.56	4.20	0.020	0.155
	100	1.26	290.53	43.86	1.73	0.057	0.200
1991	0	1.80	236.96	29.66	0.30	0.035	0.092
	50	2.20	182.40	29.46	0.40	0.032	0.117
	100	1.66	182.33	42.86	3.06	0.047	0.190
2008	0	1.56	245.06	45.46	4.43	0.015	0.000
	50	1.56	247.96	43.83	3.16	0.020	0.115
	100	3.06	210.83	24.46	2.00	0.040	0.202
2013	0	2.23	363.40	27.10	6.00	0.025	0.137
	50	1.43	224.86	28.56	3.33	0.020	0.120
	100	1.66	216.30	18.96	3.03	0.030	0.177
Control		1.56	246.90	40.63	7.36	0.007	0.160
LSD at 0.05		ns	72.48*	10.16**	3.45**	ns	0.0001**

ns: Not significant at $p \leq 0.05$; *, **: Significant at $P \leq 0.05$ and 0.01 , respectively

For the heavy metals in leaves, Table 3 clarified the combined effect of tower ages and distances on the heavy metal contents of *Calotropis procera*. There are clear significant differences among different locations and distances. Ba was high in 1991 tower at 50 m (4.23 mg/kg) and low at 1981-tower at 50 m (1.20 mg/kg), while Pb recorded high value at 2013-tower at 100 m (2.60 mg/kg), Ti-content was 428.1 mg/kg at 2013-tower at (0) distance, and V had the value of 6.66 mg/kg at 2013-tower at 0 distance.

For the heavy metals content of soil, it showed significant differences on the concentration of Ba and V at $p \leq 0.01$ and lead $p \leq 0.05$, respectively, whereas the content Ti was not significantly affected. In tower 1981, the concentration of Ba (0.1, 0.187, 0.335 mg/kg) in the soil at distances (0, 50, 100 m, respectively) increased with the increasing of distance. Furthermore, the concentrations of Pb (0.007, 0.012, 0.020 mg/kg) increased with the increasing of distance. On the other hand, the concentration of Ti (0.00) and V (0.075 mg/kg) was decreased with the increasing of distance at (100 m). In tower 1991, Pb concentrations of 0.035, 0.030, 0.022 mg/kg and Ti concentrations of 3.67, 0.00, 0.00 mg/kg in the soil were decreased with the distance increased. However, Ba and V showed irregular response with the interaction of tower establishing time and soil sampling distance. In tower 2008, Ba concentrations of 0.195, 0.255, 0.230 mg/kg, Pb concentrations of 0.027, 0.025, 0.035 mg/kg and V concentrations of 0.047, 0.062, 0.062 mg/kg were significantly increased with the distance increased and vice versa for Ti. In tower 2013, Ba had the maximum value (1.112 mg/kg) at (0) distance and the minimum (0.145 mg/kg) at 50 m. Pb increased with the distance increasing. The Ti was 0 mg/kg at 0 and 100 m distance, while at 50 m was (5.36 mg/kg). V was not significantly affected.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

Table 3: Means of heavy metals concentrations (mg/kg DW plant) in investigated plants as affected by the combined locations and its distances.

Treatments	mg/ kg in leaves				mg/ kg in soil				
	Ba	Pb	Ti	V	Ba	Pb	Ti	V	
1981	0	1.90	0.66	308.9	4.20	0.100	0.007	17.39	0.042
	50	1.20	1.20	265.1	2.40	0.187	0.012	0.00	0.017
	100	1.73	0.33	377.5	5.53	0.335	0.020	0.00	0.000
1991	0	2.80	0.56	273.0	4.46	0.132	0.035	3.67	0.035
	50	4.23	0.33	178.3	4.00	0.070	0.030	0.00	0.090
	100	3.50	0.33	174.9	3.66	0.297	0.022	0.00	0.077
2008	0	2.10	0.53	301.1	5.40	0.195	0.027	30.72	0.047
	50	2.76	0.30	295.0	4.73	0.255	0.025	5.83	0.062
	100	1.23	0.30	282.3	4.66	0.230	0.035	0.00	0.062
2013	0	2.50	0.36	428.1	6.66	1.112	0.027	0.00	0.77
	50	2.70	0.50	215.2	2.90	0.145	0.035	5.36	0.077
	100	1.66	2.60	227.9	5.06	0.210	0.045	0.00	0.075
Control		3.66	0.40	259.9	7.26	0.205	0.205	0.027	0.00
LSD at 0.05		0.68**	1.25*	23.56*	1.87**	0.39**	0.004*	ns	0.01**

ns: Not significant at $p \leq 0.05$; *, **: Significant at $P \leq 0.05$ and 0.01 , respectively

Al varied from 278.8 mg/kg DW for tower 1981 at (0) distance to 142.96 mg/kg DW for tower 1991 at (100m). Cr varied from 11.83 mg/kg DW for tower 1991 at (0) distance to 6.83 mg/kg DW for tower 2013 at 100 m. Ga shows low values, while Ni varies from 5.36 mg/kg DW at tower 1981 at 50 m to 23.96 mg/kg DW at tower 2013 at 100 m (Table 4).

Table 4: Means of toxic metals concentrations (mg/kg DW plant) in investigated plants as affected by the combined locations and its distances.

Treatments	Toxic Metals (mg/kg DW plant)				
	Al	Cr	Ga	Ni	
1981	0	189.86	11.03	2.56	7.43
	50	193.73	8.73	2.40	5.36
	100	278.80	9.76	3.20	5.90
1991	0	187.73	11.83	2.50	7.86
	50	146.50	9.26	1.66	6.36
	100	142.96	10.36	1.60	6.66
2008	0	207.63	10.16	2.70	6.30
	50	201.70	10.46	2.80	6.90
	100	170.13	9.56	2.40	6.16
2013	0	291.93	11.13	3.70	6.86
	50	178.86	9.16	2.06	5.86
	100	157.10	6.83	1.73	23.96
Control		205.96	10.16	2.23	6.46
LSD at 0.05		62.05**	ns	0.86*	ns

ns: Not significant at $p \leq 0.05$; *, **: Significant at $P \leq 0.05$ and 0.01 , respectively

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

IV. DISCUSSION

Studying the relationship between magnetic field and plant response is becoming more important as new evidences to clarify the ability of plants to perceive and respond quickly to varying magnetic field by altering their gene expression and phenotype. The recent implications of magnetic field reversal with plant evolution open new horizons not only in plant science but also to the whole biosphere, from the simplest organisms to human beings [34].

Micro-nutrient results indicated that Cu, Fe, Mn, Zn, were high in (0) m distance a part at all towers age, this is in consistent with the results of Esitken and Turan [3]. On the other hand, Fe is involved in many important compounds and physiological process in plants such as in chloroplast and some protein formations although it is required by plant in small amounts [18]. Excessive Na has detrimental effects on electron transport and photosynthesis, and it also affects through stomatal closure [35] which reduces assimilates supply. Excessive Na may also disrupt the cell wall and increase the permeability of the cell membrane, leading to increased solute leakage from leaves at high salt concentration.

Amiri and Dadkhah [16] found that changes in surface tension due to magnetic treatment can be a key point in tracing impurities in water. Furthermore, Johnson and Guy [17] and Moon and Chung [3] have reported that external electric and magnetic fields influence activation of ions in living cells. These findings are very important for interpretation the differences in micronutrients between virgin and induced sites.

Previous studies showed that magnetic field has an effect in increasing the nutrients uptake. Duarte Diaz [5] reported an increase in nutrient uptake by magnetic treatment in tomatoes. A remarked increase in P content of citrus leaves by magnetic water was also reported by Hilal and Hilal [11].

When analysing the results of the toxic elements in plants in term of Ba, Pb, Ti and V, it was noticeable that fortunately Ba and Pb are found in trace amounts. However, Ti and V are high especially in case of Ti. The role of Ti in plants metabolism is not truly clear. Some authors indicated that it enhances the growth of leaves for some plants and it can be mainly accumulated in assimilation organs and hence, it is able to intensify plant growth and development as well as increasing intensity at green colour (higher Chlorophyll content), as was reported by Tlustos *et al.* [20]. This can also explain the high chlorophyll content in *Calotropis procera* in our previous study Alaish and Al-Zahrani [24].

Concerning V, it has a role in plant nutrition and it was found to be toxic in many plants and can retard the growth of tomato plants when 40mg/L exceeded [7]. However, *Calotropis procera* was not affected in the present study by the high quantity of vanadium mainly, because of the presence of the latex which increases protection to the leaves [23]. Results of elements in soil showed higher amounts of macro elements at all distances and tower ages compared to plants. Surprisingly, the toxic elements in terms of barium, lead, titanium and vanadium indicating that *Calotropis procera* is a good phytoremediator to the soil. Freeman *et al.* [22] through their investigation of the effect of EMF on soil elements confirmed that neither pH nor concentration of Ca, Cu, Fe, K, Mg, Mo, Pb or Zn differed with distance from the source.

V. CONCLUSION

- Ferrous, manganese and zinc were affected significantly by the interaction effect of establishing time and distances, while copper was not significantly affected.
- The combined effect of tower ages and distances on the heavy metal contents of *Calotropis procera* showed clear significant differences among different locations and distances.
- The interaction effect of installations times of electricity towers and distances showed that aluminium and gallium were significantly affected whereas chromium and nickel were not significantly affected by both factors.
- All investigated sites under the effect of electromagnetic field showed no considerable variations compared to the control.
- All soils are slightly alkaline and none saline. Soil texture for all sites were sandy except in 1981 tower site whereby the texture was sandy loam.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

- The highest electrical conductivity value was recorded at Tower 2008 at 100 m which is 2.526 mS/cm, while the lowest value was recorded at tower 2008 at (0) distance which is 0.307 mS/cm.
- Copper and zinc were significantly affected by establishing time of electricity towers.
- The content of copper and zinc were affected significantly in all investigated sites by the distances at $p \leq 0.01$. For both nutrients, the concentration was decreased significantly with the increase of the distance.
- The interaction effect of towers establishing time and distances have no effect on the content of copper, whereas the of content zinc was significantly affected at $p \leq 0.01$. The content of zinc was increased linearly in all investigated sites with increase of the distance.
- The interaction effect of establishing time and soil sampling distances showed significant differences on the concentration of barium and vanadium at $p \leq 0.01$ and lead $p \leq 0.05$, whereas the content titanium was not significantly affected.

REFERENCES

- [1] Annual Report of Saudi Electricity Company, (2013).
- [2] http://www.se.com.sa/NR/rdonlyres/2F4F7D9134DC471188F7826FBB9DF80/SE_EN_AnnualReport2013.Pdf.
- [3] C.C. Johnson, and A.W. Guy, "Non-ionizing electrostatic wave effects in biological materials and systems", Proc. IEEE, vol. 60, no. 6, PP. 692-718, 1972.
- [4] J.D. Moon, and H.S.Chung, "Acceleration of germination of tomato seed by applying AC electric and magnetic fields", Journal of Electrostatics, vol. 48, no.2, pp. 103-114, 2000.
- [5] Esitken, A. and Turan, M. (2004). "Alternating magnetic field effects on yield and plant nutrient element composition of strawberry (*Fragaria x ananassa* cv. Camarosa)", Acta Agric. Scand, vol. 54, pp. 135-139, 2004.
- [6] Duarte Diaz, C.E. Riquenes, J.A., Sotolongo, B., Portuondo, M.A., Quintana, E.O., and Perez, R., "Effects of magnetic treatment of irrigation water on the tomato crop", HortAbst, vol. 69: 494, 1997.
- [7] Pakhmov, V.M., "The state of physiological depression of cells of excised roots disturbance or adaptation", Biology Bulletin of the Russian Academy of Science, vol. 19, pp. 6-17, 1992.
- [8] Dhawi, F.; Al-Khayri, J. and Essam, H., "Static Magnetic Field Influence on Elements Composition in Date Palm (*Phoenix dactylifera* L.)", Research Journal of Agriculture and Biological Sciences, vol. 5, no. 2, pp. 161-166, 2009.
- [9] Martinez, E.; Carbonell, M. and Amaya, J., "A static magnetic field of 125 mT stimulates the initial growth stages of barley (*Hordeum vulgare* L.)", Electro Magnetobiol, vol. 19: pp. 271-277, 2000.
- [10] Hanafy, M.S.; Mohamed, H.A. and Abd El-Hady, E.A., "Effect of low frequency electric field on growth characteristics and protein molecular structure of the wheat plant", Rom. J. Biophys., vol. 16, no. 4, pp. 253-271, 2006.
- [11] Freeman, C.D.; Graham, J.H.; Tracy, M.; Emlen, J.M. and Alados, C.L., "Developmental instability as a means of assessing stress in plants: a case study using electromagnetic fields and soybeans", Int. J. Plant Sci., vol. 160, no. 6, pp. 157-166, 1999.
- [12] Hilal, M.H. and Hillal, M.M., "Application of magnetic technologies in desert agriculture .1-Seed germination and seedling emergence of some crop in a saline calcareous soil", Egypt J. Soil Sci, vol. 40, no. 3, pp. 413-421, 2000.
- [13] Tai, C.Y.; Wu, C.K. and Chang, M.C., "Effects of magnetic field on the crystallization of CaCO_3 using permanent magnets", Chem. Engin. Sci., vol. 63, pp. 5606-5612, 2008.
- [14] Chibowski, E.; Holysz, L.; Szczes, A. and Chibowski, M., "Precipitation of calcium carbonate from magnetically treated sodium carbonate solution", Colloids Surf, vol. 225, pp. 63-73, 2003.
- [15] Cho, Y.I. and Lee, S.H., "Reduction in the surface tension of water due to physical water treatment for fouling control in heat exchangers", Int. Commun. Heat Mass Transfers, vol. 1, no. 1-9, 2005.
- [16] Limpert, G.J.C. and Raber, J.L., "Tests of non-chemical scale control devices in a once-through system", Mater Performance, vol. 24, no. 40-45, 1985.
- [17] Amiri, M.C. and Dadkhah, A.A., "On reduction in the surface tension of water due to magnetic treatment", Colloids Surf A. Physicochem Eng Aspects, vol. 278, pp. 252-255, 2006.
- [18] Johnson, C.C. and Guy, A.W., "Non-ionizing electrostatic wave effects in biological materials and systems", Proc. IEEE, vol. 60, no. 6, pp. 692-718, 1972.
- [19] RamezaniVishki, F.; Majd, A.; NejadSattari, T. and Arbabian, P.S., "Study of Effects of Extremely Low Frequency Electromagnetic radiation on biochemical changes in *Saturejabachtiarica* L.", International Journal of Scientific & Technology Research, vol. 1, no. 7, pp. 77-82, 2012.
- [20] RamezaniVishki, F.; Majd, A.; NejadSattari, T. and Arbabian, S., "Effects of electromagnetic field radiation on inducing physiological and biochemical changes in *Saturejabachtiarica* L.", Iranian Journal of Plant Physiology, vol. 2(4): 509-516, 2012.
- [21] Tlustos, P.; Cigler, P.; Hruby, M.; Kuzel, S.; Szakova, J. and Balík, J., "The role of titanium in biomass production and its influence on essential elements contents in field growing crops", Plant Soil Environ, vol. 51(1), pp. 19-25, 2005.
- [22] Kumar, V.L. and Arya, S., "Medicinal uses and pharmacological properties of *Calotropis procera*", Recent Progress in Medicinal Plants, vol. 11, pp. 373-388, 2006.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

- [23] Freeman, C.D.; Graham, J.H.; Tracy, M.; Emlen, J.M. and Alados, C.L., "Developmental instability as a means of assessing stress in plants: a case study using electromagnetic fields and soybeans". Int. J. Plant Sci., vol. 160, 6, pp. 157-166, 1999.
- [24] Alaish, F. M. Z. "Impact of electromagnetic fields of high voltages transmission lines on plants in Makkah Al-Mukaramah region", PhD thesis. Faculty of Science. King Abdullaziz University. Jeddah, Saudi Arabia, 2015.
- [25] Alaish, F. M. Z. and Al-Zahrani, H. S. M., "Biological activity of *Calotropis procera* grown under high voltage transmission lines in Jeddah province", Saudi Arabia. International Journal of Innovative Research in Science, Engineering and Technology. vol. 3, no. 12, pp. 18184-18192, 2014.
- [26] Alaish, F. M. Z., Al-Zahrani, H. S. M. and Hindi, S. S. Z., "Environmental impacts of electromagnetic radiation induced by high voltage-power lines", International Journal of Innovative Research in Science, Engineering and Technology. vol.5, no. 2, pp. 627-634, 2016^a.
- [27] Alaish, F. M. Z., Al-Zahrani, H. S. M. and Hindi, S. S. Z., "Some stomatal aspects of *Calotropis procera* as induced by high voltage-power lines", International Journal of Innovative Research in Science, Engineering and Technology. vol.5 (2): 1111-1126, 2016^b.
- [28] Fatima M. Z. Alaish, Hassan S. M. Al-Zahrani and Sherif S. Z. Hindi., "Some metabolic activities of *Calotropis procera* as affected by electromagnetic field induced by high voltage-power lines", International Journal of Innovative Research in Science, Engineering and Technology. vol. 5, no. 3, pp. 1111-1126, 2016^c.
- [29] Hindi, S. S. Z., "Calotropis procera: The miracle shrub in the Arabian peninsula. International", Journal of Science and Engineering Investigations (IJSEI), vol. 2, no. 16, pp. 10, 2013.
- [30] Humphris, E.C., "Mineral components and ash analysis in modern methods of plant analysis by K Peach and M.V. Tracey", eds. Berlin, Heidelberg: Springer Verlag, vol. 1: 468-502, 1956.
- [31] Stewart, G.R.; Lee, J.A. and Orebamjo, T.O., "Nitrogen metabolism of halophytes. Nitratereductase activity in *Suaedamaritime*", New Phytol., vol.71, pp. 263-267, 1972.
- [32] McLean, E.O., "Soil pH and lime requirement", In: Page AL Miller RH, Keeney DR (eds) Methods of soil analysis. Part 2. Chemical and microbiological properties. Agron. Monograph, 2nd ed. Am. Soc. Agron and SSSA, Madison, WI., vol. 9, pp. 199-223, 1982.
- [33] Black, C.A.; Evans, D.D.; White, J.L.; Ensminger, L.E.; Clark, F.E. and Dinauer, R.C., "Methods of soil analysis", Am. Soc. Agron. Monogr, vol.9, pp. 1572 (In 2-parts). Madison, Wis USA, 1965.
- [34] Jackson, M.L., "Soil chemical analysis", Prentice Hall of India Pvt. Ltd, New Delhi, India, pp. 205, 1967.
- [35] Maffei, M.E. "Magnetic field effects on plant growth, development, and evolution", FrontPlant Sci., vol.5, pp. 445, 2014.
- [36] Muranaka, S. Shimizu, K. and Kato, M., "Ionic and osmotic effects of salinity on single-leaf photosynthesis in two wheat cultivars with different drought tolerance", Photosynthetica, vol.40: 201-207, 2002.