Extended Essay

Is the photosynthesis rate of *Elodea Canadensis* affected by electrical field's presence and varying strength?

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Abstract

Living organisms are known to be affected by “electrosmogs” which refers to the electrical and magnetic fields in the earth. These fields are said to have a bad impact on the human health yet their effect on the other living organisms like plants is not taken into account. Even if the presence of the studies on the magnetic fields' effect to the plants cannot be denied, there is no systematic study on the electrical field effect to the plants' photosynthesis rate. Seeing this absence, this essay is centered on the effect of varying electrical field’s strength on *Elodea canadensis. E. canadensis* is chosen because it is a common plant that can be found in many aquatic ecosystems, an important source of O_2 for the water ecosystem and an indispensable part of the primary production of the ecosystem. In order to answer the research question, a fixed number of elodea was subjected to the different electrical field strengths, and the dissolved O_2 concentration in the water was measured with data loggers in order to determine the photosynthesis rate.

At the end of the experiment, when the results were analyzed by using ANOVA, it is found that as the electrical field strength increased, the dissolved O_2 concentration didn't change significantly indicating the rate of photosynthesis is not affected by the increase in the electrical field strength. Thus, the analysis of the data does not support the hypothesis. However when the means of the experimental groups photosynthesis rates are compared to the control group' s, it can be said that if *Elodea Canadensis* was exposed to higher electrical field strength , then a obvious change would be observed. The hypothesis might not supported due to some systematic and random errors or simply because of inadequacy of the strength of the electrical field that could not interfere with the photosynthesis procedure.

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Introduction

Even if we do not see, there are some forces on the world that we are subjected like electrical and magnetic fields. With the development of technological devices that we are using, these forces became an indispensable parts of our life. The various electrical and magnetic fields in the environment are often called “electro smog"[1]. Electro smog is said to have long term or short term effects on people like occurrence of headaches, exhaustion, allergies, genetic damages or cancer depending on the range of frequency and field strength. If they have these effects on humans, it is not hard to imagine what kind of effects they have on the other species.

At the light of this information, I decided to center my experiment on electro smog's effect on other living organisms and made some search on it. I came across with a video[2] that shows some plants that is exposed to electrical and magnetic fields .Seeing this video inspired me to observe the electrical field’s effect on the plants considering electrical field is one of the factors that causes electro smog. Although there are lots of article and research about electrical field's effects on human beings, I was unable to find any search that focuses specifically on this subject , apart from the ones that observe the electrical and magnetic fields effect on the appearance of the plants or study electro smog's general impacts on ecosystem. The absence of this kind of research led me to explore the possible effects of the electrical field on the plants. I knew that plants have an important role in the flow of energy in the ecosystems that comes from their ability to capture light energy through the process of photosynthesis. As a result, I thought it would be sensible to explore the electrical field's effect on the photosynthesis to determine the impact of these waves can have on the living organism life. Thus I decided to focus on electrical field's effect on the plant's photosynthesis rate.

Considering, I chose to work on plants because of their role in the ecosystem, it might be more useful to make experiment on a type of plant that can be found in all ecosystems. However in this case apart from abundance, the plant's vulnerability to electrical field is also important to detect the effects more clearly. Seeing this need, using a type of plant that has no cuticle would be better. I specifically chose a plant without cuticle so that there will be no barrier

[1] "Through The Trees." *: The Electromagnetic Field Effects on Plants*. Web. 16 Jan. 2015. <http://wellearthopedia.blogspot.com.tr/2013/03/the-electromagnetic-field-effects-on.html>.

[2] "Electromagnetic Interference (EMI) and AC Electric Field Effects on Plants." *YouTube*. YouTube. Web. 12 Feb. 2015. <https://www.youtube.com/watch?v=rbmlS_nvQcE>.

to interfere with the electrical field thus the effects can be observed more effectively. Apart from these, the plant that is aimed to be selected should be an aquatic plant, since determining the dissolved oxygen level in the water as an indication of photosynthesis rate in an aquatic plant would be more accurate and easier than any terrestrial plants'. This is why *Elodea canadensis* is selected to be used in this experiment. *Elodea canadensis* is an invasive species in Europe, Asia, Africa, and Australia and an aquatic plant which indicates it has no cuticle. On the other hand, elodea is selected because it is one of the many aquatic plants that raises the dissolved oxygen level along with the primary productivity by making photosynthesis .On other hand , at the end photosynthesis ,organic material is synthesized, as the rate of photosynthesis increase the mass of the produced glucose will increase thus the primary productivity. Considering that when the plant dies or it is eaten the energy that is stored in form of glucose will be transferred to the other living organism. However if photosynthesis rate is decreased then the carrying capacity of the ecosystem can decrease which may result in death of the fishes and the other heterotrophic living beings. Therefore the large habitat of elodea signals that focusing on this aquatic plants may give us a general idea about electrical field's impact on the aquatic ecosystems.

With all of the aspects that is mentioned above this topic is worthy to study in order to see the effects of the electrical fields on the other natural beings rather than human. Consequently, this essay will be centered on the research question "**Is the rate photosynthesis procedure of *Elodea canadensis* is affected by electrical field's presence and varying strength ?"**. Moreover, I will discuss the development of a proper method, and the precision and accuracy of the data that is handled and analyze the electro smog's possible effect on aquatic ecosystem and its energy flow.

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Hypothesis

There are some recent researches on magnetic fields effects on the plant ecosystem. N.A. Belyavskaya[3] from Institute of Botany found that weak electromagnetic fields suppressed the growth of plants, reduced cell division, intensified protein synthesis and disintegration in plant roots. Moreover,
a study that took place in Islamic Azad University found a significant decrease in the rate of chlorophyll a and chlorophyll b. However, carotenoid and activity of non-enzymatic antioxidant content in treatment samples significantly increased in comparison with control plants[4]. Even if the results seems to contradict, it indicates that magnetic field does have an effect on plants one way or another. Considering the similarity between the electrical and magnetic field, the electrical field is likely to effect the functioning of photosynthesis.

On the other hand presence of electron transport system in the process of photosynthesis which indicates the presence of electrons can be used as an evidence to hypothesize electrical field will affect the photosynthesis rate, since electrical field lines attracts the electrons. On the light of this information, it is proposed that increasing strength of the electrical field will decrease the dissolved oxygen concentration of the water indicating the photosynthesis slows down.

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3. "Through The Trees." *Through The Trees*. 1 Jan. 2004. Web. 11 Feb. 2015. <http://wellearthopedia.blogspot.com.tr/>.

4 24 Oct. 2012. Web. 6 Jan. 2015. <http://ijpp.iau-saveh.ac.ir/Files/Journal/2012-10-24_02.42.59_2. Dr arbabian.pdf>

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Method Development and Planning

Planning an appropriate method which can be helpful to obtain accurate and precise data came up with some problems. The first one was to find how to measure the dissolved oxygen level as an indication of the photosynthesis functioning. Surely, the data logger should be used with a dissolved oxygen level probe yet if a tap water was used then observing a significant change would take a long time that anticipated. Therefore, adding the adequate amount of calcium carbonate which is 15 grams would increase the dissolved CO_2 in the water thus provide more CO_2 to be used by plants to produce O_2. Through this, any possible change would be determined with sharp decreases and increases so that cannot be mistaken as an error.

Secondly , *E. canadensis* were agreed to be cut in the same length assuming they have same number of leafs in order to keep the electrical field's flux constant . However *E. canadensis*' position in the beaker was still a problem since the movement of *E. canadensis* might change the electrical flux , thus the strength of the electrical field that it is subjected . In this case the data would lose their precision and create a source of systematic error. In order to keep the strength of the electrical field constant for the each experimental group. *E. canadensis* were decided to be tied to the beaker with the help of sewing threads without harming the leafs , so that their position in the water is help constant.

The third problem was to determine the strength of the electrical field that these species are possibly prone to in their habitat. However the electrical field strength varies from time to time and place to place so it would be safe to focus on the increase in electrical field strength starting from 750 V/m. It is assumed that 750 V/m is the average electrical field strength that *E. canadensis* living in a freshwater body near the city can be subjected considering it is not located near the industrial area. Increasing the electrical field strength from 750 V/m to 2750 V/m might give us an idea about what would happen to the photosynthesis rate ,if the plant is subjected to a more powerful electrical field. It can be said, the increase in the electrical field strength is due to the new industrial firms are built near the habitat of *E. canadensis* or simply the usage of electrical devices increased with the growing population.

After developing an appropriate method, the necessity of monitoring the variables that might affect the course of the experiment other than electrical field aroused. The factors such as

light intensity, temperature of the water and the room, pH of the water, concentration of dissolved carbon dioxide in the water and the distance between the plates might promote or decrease the effect of the electrical field or interfere with the collection of an accurate data.

In order to keep the light intensity constant for each experimental group a few trials has been made to decide the best distance from the table. At the end of these trials lamps were decided to fixed at 30 cm away from the table and 10 cm away from the each other that each experimental group can take light from each one of the lamps. On the other hand the experiment was decided to be performed in a dark room so that no light rather than the intended source's may enter the system. While setting these measurement the heat energy that the lamps could have gave off, was also taken into account through this method also the temperature of the water was kept constant. In order to control the temperature of the water at 21 °, a thermometer was put into the beaker to see any change before after and during the experiment. However temperature is an important element in the rate of photosynthesis so if it cannot be kept constant then the results would change regardless of the effect of electrical field which causes an error. In this case if temperature increases an ice cubes will be added to solution to have an instant decrease and if temperature decreases then a water bath will be used to obtain initial temperature. To keep the room temperature constant a experiment will be performed in a lab with a constant temperature.

The optimum pH value for *Elodea canadensis* is between 6.5 and 7, as a result the pH of the water should be kept between this range. To provide these conditions the pH value of the water solution was controlled by a pH paper before and after the experiment. On the other hand the amount of calcium carbonate has been decided to be 15 gram so that the pH value will be between 6.5 and 7 since amount of calcium carbonate is the only variable that can affect pH of the water.

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Method

Materials and Apparatus:

3 glass beaker of 500 ml	Elodea Canadensis	2 connection cable
Light source (5 lamps)	spatulas	sodium carbonates
Power supply (1 battery)	dissolved oxygen probe	1 spoon
pH paper	data logger (Vernier®)	sewing threads
scissors	ruler (1m)	chronometer
water (tap water is adequate)	2 copper plates	

Preparing the set up for the experiment:

1. Secure 2 copper plates is with the help of a wooden stand .
2. Connect the plates to the power supply by the help of two connection cable for the each copper plates.
3. Separate the metal plates 10 cm apart by using a ruler .

Procedure of the experiment :

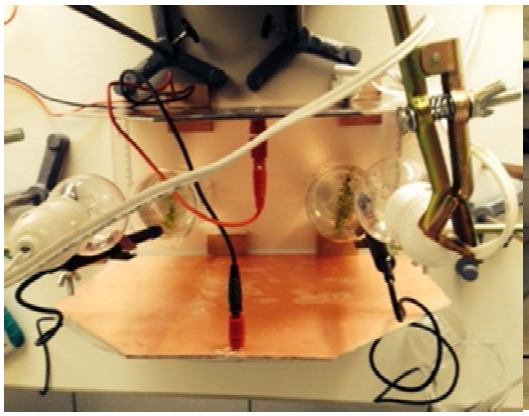
1) Fill three beakers with 500 ml of tap water.
2) Add 1 spoon (15 g) of sodium carbonates to each beaker.
3) Stir the solution with the help of spatulas till there is no precipitation left at the bottom (make sure that dissolution process is over by controlling precipitation at the bottom).
4) Cut *Elodea canadensis* plants into 7 cm by using ruler and scissors .*E. canadensis* plants are in the same length.
5) Place two of *Elodea canadensis* pieces into a beaker.
6) Tie *Elodea canadensis* by sewing threads to the beaker without damaging the plant.
7) Label two beaker as experimental group1 and 2.

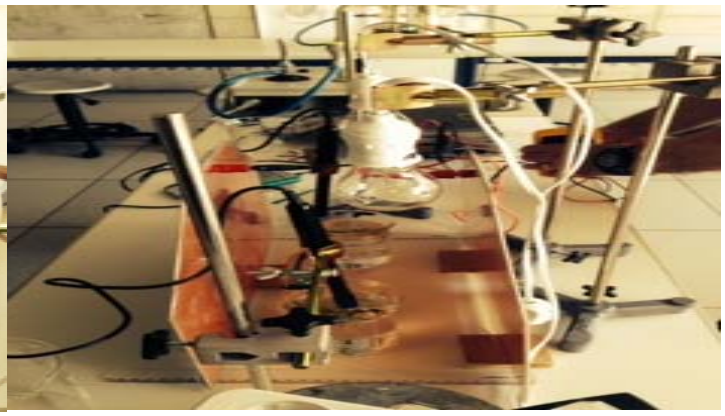
8) Place the beakers between two copper plates.
9) Fix two identical lambs 30 cm above the set - up so that each beaker received equal amount of light , noting that each lamp is on the top of the each beaker and 10 cm apart from each other.
10) Place the data loggers with dissolved oxygen probes to the beakers and fixed them with a stand.
11) Set battery to 75 volt and turn on for the both experimental groups.
12) Switch the lights on at the same time for both of the experimental groups.
13) Program the data loggers to take 1 measure for each minute.
14) Start the data loggers at the same time for the both of the experimental groups.
15) The duration of experiment is 30 minutes so at the end of 30 minutes stop the data logger immediately.
16) Repeat all of the steps for each of voltage levels which are 175V and 275V precisely for the experimental groups .
17) For the control group repeat all of the steps except step 8 and 11.
18) Repeat the whole procedure 4 more times.

Procedure for keeping the constant variables constant:

- Measure pH and temperature before and after the experiment. Note it if two data are different from each other.
- Perform the experiment in a room with constant temperature.
- Place a thermometer to every experimental group for each trial. Check the thermometer constantly if any change occurs. If temperature increases use water bath to prevent the heating of the beaker and the water. If temperature decreases add ice cubes to the beaker.

Pictures of the Experiment:





Picture 1: The experiment set-up is shown in the pictures that are given above

Data Analysis

Even though, one measurement was taken per 2 minute during experiment (period of the experiment is 30 minute) with data logger, the data of the 30th minute is used to analyze the effects of the electrical field. Data of the other minutes is given in the appendix 1 for the each trial and electrical field strength

Electrical field's voltage	Number of trials	Dissolved Oxygen Level	Temperature of the water (± 0.1°C)	pH of the water (±1)	Length of E.Canadensis (±0.1cm)	Mass of sodium bicarbonate (± 0.1 g)	Distance between the plates (± 0.1 cm)
0	Trial 1	3.0	21.0	7	7.0	15.0	10.0
	Trial 2	4.0	21.0	7	7.0	15.0	10.0
	Trial 3	3.0	21.0	7	7.0	15.0	10.0
	Trial 4	3.9	21.0	7	7.0	15.0	10.0
	Trial 5	3.8	21.0	7	7.0	15.0	10.0
75	Trial 1	3.2	21.0	7	7.0	15.0	10.0
	Trial 2	5.1	21.0	7	7.0	15.0	10.0
	Trial 3	5.1	21.0	7	7.0	15.0	10.0
	Trial 4	3.2	21.0	7	7.0	15.0	10.0
	Trial 5	6.8	21.0	7	7.0	15.0	10.0
175	Trial 1	3.2	21.0	7	7.0	15.0	10.0
	Trial 2	6.3	21.0	7	7.0	15.0	10.0
	Trial 3	6.3	21.0	7	7.0	15.0	10.0
	Trial 4	3.0	21.0	7	7.0	15.0	10.0
	Trial 5	6.3	21.0	7	7.0	15.0	10.0
275	Trial 1	4.7	21.0	7	7.0	15.0	10.0
	Trial 2	4.8	21.0	7	7.0	15.0	10.0
	Trial 3	4.6	21.0	7	7.0	15.0	10.0
	Trial 4	4.5	21.0	7	7.0	15.0	10.0
	Trial 5	5.0	21.0	7	7.0	15.0	10.0

Table 1: shows the dissolved oxygen level released in the 30th minute due to photosynthesis of E. canadensis when it is exposed to varying electrical field voltage (0 V,75 V,175 V,275 V) and when the factors that may affect the rate of photosynthesis such as temperature of water , duration of experiment, pH of water ,distance between plates and the mass of sodium bicarbonate are kept constant for the each trial.

The following formula were used to obtain the means and the standard deviations of the each groups of data.

Mean: [5]

$$\bar{X} = \frac{\Sigma X}{N}$$

Where:

$\bar{X}$ is the symbol for the mean.

Σ is the symbol for summation.

X is the symbol for the value in data set.

N is the symbol for the number of data.

A model calculation for the mean of all of the 5 trials of the 275 V (DC) shown below:

$$\bar{X} = \frac{(4.7 + 4.8 + 4.6 + 4.5 + 5.0)}{5}$$

$$= 3.54$$

[5] "1: Mean, Median, and Mode." *1: Mean, Median, and Mode*. Web. 1 Jan. 2015. <http://www.fgse.nova.edu/edl/secure/stats/lesson1.htm>

Standard Deviation:[6]

$$\sigma = \sqrt{\frac{\Sigma\ (x-\bar{x})^2}{n}}$$

Where:

$\bar{X}$ is the symbol for the mean.

Σ is the symbol for summation.

X is the symbol for the value in data set.

N is the symbol for the number of data.

A model calculation for the standard deviation of the dissolved oxygen level 275 V (DC) shown below:

$\sigma=\sqrt{[(}\ (4.7-3.54)^2+(4.6-3.54)^2+(4.5-3.54)^2+(5.0-3.54)^2+(4.8-3.54)^2/4]$

$=0.248$

6 "Standard Deviation." *Standard Deviation*. 16 Jan. 2015. Web. 16 Jan. 2015. <http://geographyfieldwork.com/StandardDeviation1.htm>

Strength of Electrical Field:

The formula that is given below was used to calculate the electrical field strength between parallel plates:[7]

E= $\boldsymbol{\frac{V}{d}}$ Volt/Meter

Where:

V is the potential difference between two parallel plates

d is the separation between plates

E is the electrical field strength

Model calculation for the electrical field strength:

10 cm = 0.1 m

$$\frac{275}{0.10}$$

E= 2750 V/m

[7] Tsokos, K. A. "Electric Field and Electric Potential." *Physics for IB Diploma*. Fifth Edition ed. Cambridge UP, 2019. Print.

Electrical field strength	Mean of the dissolved oxygen level
CONTROL GROUP	4.72
75	4.36
175	4.68
275	3.54

Table 2: The means of the dissolved oxygen level in the 30th minute which is released by *E. canadensis* during the photosynthesis for each electrical field strength that E. Canadensis is exposed.

Groups / Parameter	*CONTROL GROUP*	*750*	*1750*	*2750*
Mean	4.72	4.36	4.68	3.54
Standard Error	0.09	0.80	0.68	0.22
Standard Deviation	0.19	1.77	1.52	0.50
Confidence Level(95,0%)	0.24	2.20	1.85	0.62

Table 3: The Descriptive analysis for each electrical field strength. The data that is given above is calculated by using Microsoft Office Excel.

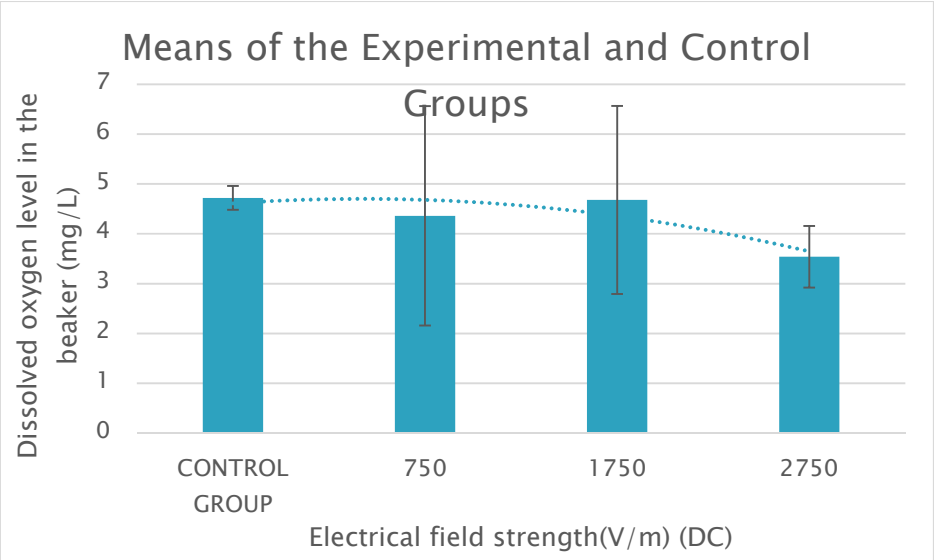
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.49	3	1.49	1.05	0.39	3.24
Within Groups	22.94	16	1.43			

Table 4: Single factor Analysis of Variance (Anova) statistical calculation for all groups

H_0: There is not a significant mean difference between dissolved O_2 levels produced by photosynthesis of *Elodea canadensis* when it is exposed to varying strength of electrical field .

H_1: There is a significant mean difference between dissolved O_2 levels produced by photosynthesis of *Elodea canadensis* when it is exposed to varying strength of electrical field .

P is 0.39 .As p > 0.05 Ho is accepted.



Graph 1: The graph of the means of the released oxygen level due to photosynthesis of *E. canadensis* when it is exposed to the varying electrical field strengths from 0 V/m (DC) to 2750 V/m(DC) is shown above when pH and temperature of water, mass of sodium bicarbonate and distance between the two plates is kept constant .The error bars shows a standard deviation for each group.

Evaluation

The aim of this study was to observe the effects of increasing electrical field strengths to the photosynthesis rate of *Elodea canadensis*. Before the experiment, it was proposed that there would be a decrease in the dissolved oxygen level in indicating photosynthesis rate slows down as the strength of the electrical field is increased

All of the groups that is subjected to different electrical field strength more or less showed the same photosynthesis rate with the control group which was not subjected any electrical field. The electrical field strength that is applied changed between 0 to 275 Volts with the mean value of 3.54 for the 275 V, 4.68 for 175 V, 4.36 for 75 V and 4.72 for the control group. The largest mean is 4.68 whereas the smallest is 3.54 although there is a change it is too small and seems unable to support my hypothesis.

My null hypothesis was that there would not be a significant difference between the means of dissolved oxygen levels of the control group and the groups that are subjected to varying electrical fields indicating the photosynthesis rate of the *Elodea canadensis*. In order to test the null hypothesis the p values of the pair-wise comparison of the groups were calculated. The p values ($p= 0.39$) were found to be larger than 0.05 which shows that there is no significant mean difference between photosynthesis rate of the groups in terms of dissolved oxygen level as it can be seen in the Graph 1. When the trend of the graph is analyzed it is clear that the dissolved oxygen level varies but in the range of the error bars which indicates that this changes can be due to error sources. However, trend of the bar graph shows an obvious decrease from control group to 750 V/m and from 1750 to 2750 , also the standard deviation difference between the experimental groups and control group is high .Both of these qualities suggest that the change might have occurred if it was not diminished with the random and systematic errors. This variance in the interpretations of the result will be discussed in the following parts of the essay, yet on the light of ANOVA's results, my null hypothesis is accepted. My hypothesis which proposes that increasing strength of the electrical field will cause a change in the dissolved oxygen concentration of the water which indicates the photosynthesis rate slows down has been rejected by the results of the experiment and the analysis of the data.

Standard deviations of the each experiment group is similar yet slightly higher than the control groups (0. 50, 1.77, 1.52 and 0.19).This occurrence might signal both random and experimental error. Also these differences between the standard deviation of the control and experimental group may indicate nearly constant means of the results might be coincidental result of the any type of error.

Possible sources of each type of error can be eliminated by making a series of modification in the experiment procedure. Firstly the random errors impact on the results might be limited if the experiment is repeated more than 5 times. However, this may not be enough to reduce all of the random error sources.

In the experiment, the sodium carbonate was used to increase the dissolved CO_2 level. Thus the dissolved mass of sodium bicarbonate should be constant in order to provide each elodea an equal amount of CO_2 to use. Even if the procedure clearly stated that the experiment will not begin till there is no precipitation left, an instrument to control the dissolution of sodium carbonate was not named. Due to the absence of this kind of material, there is no way to be sure each elodea had equal amount of CO_2 to make photosynthesis , this fact may be the cause of the standard variation in the dissolved oxygen level within the trial group. A probe to measure the dissolved sodium bicarbonate amount should be used to eliminate this source of random error

Although aquatic plant is chosen to be investigated since it has no cuticle to interfere with the electrical field force, there is still a cell wall that may change the effect of electrical field. If ıt could be kept constant that would not be a problem yet, unfortunately there is no method to calculate the thicknesses without harming the plants. Besides the difference in the cell wall thickness can source of the random error.

The systematic errors in the process of measuring the dissolved oxygen levels can be reduced by decreasing the duration of the measurement from 2 minute to 0.5 second .In this way ,the instant changes in the dissolved oxygen level due varying electrical field strength can be observed better.

Even though sodium bicarbonate is dissolved in the water to increase the dissolved oxygen level, there were nothing else dissolved in the beaker except some minerals compared to its habit which has vitamins, organic materials and some dissolved gases. The lack of those

ingredients might have affect its rate of photosynthesis thus the real effect of electrical field strength on *E. canadensis* which lives in its habitat cannot be observed clearly. In order to solve this problem a water that is taken from *Elodea canadensis'* habitat can be used to preserve the qualities of its habitat.

On the other hand plants that are used in the experiment was bought from a pet shop. Thus the age or the freshness of the *Elodea canadensis* was not known clearly. This situation might have caused some standard deviations since as the plant grows up its metabolic activities starts to slow down which may trigger a variation dissolved oxygen level as an indication of photosynthesis rate. In this case it would be sensible to collect *E. canadensis* from a fresh water body. While collecting lengths of Elodea canadensis should be measured with a meter and used as an indication of age. Thus the ones that nearly have the same length should be collected and used in the experiment.

Also another commonplace aquatic plant instead of *E. canadensis* can be used in this experiment since the surface are of the leaves was pretty small which may decrease the flux. In this case, in order to observe possible effects more efficiently a plant with a wider surface area such as *Crytocoryne undulate* as can be used .By this method the number of chloroplast can also be increased which means the dissolved oxygen level can be promoted ,hence the results can be more readable for analyses.

Conclusion

At the end of this study, my research *question "Is the rate photosynthesis procedure of Elodea canadensis affected by electrical field's presence and varying strength?"* is answered. I have found that there is no significant effect of the electrical field's presence or varying strength on *Elodea canadensis* at least not in the range electrical field strengths that is applied. Thus my hypothesis is not supported by experimental results. Although the results that I have obtained contradicts with my hypothesis and the method that is used requires considerable amount of modifications, I consider this study successful in terms of seeing the effects of the electrical fields on the aquatic ecosystems.

It might be important to note that through this study the electro smog's effect on the aquatic ecosystem can be seen. However generalization of any result might cause some problems seeing the difference in the structure of the terrestrial and aquatic plants like presence and thickness of cuticle that might affect the range of the strength that can be applied by electrical field. Besides, it is possible the inability of the electrical field strengths to create a change in the photosynthesis is due to the insufficiency of electrical field range that is applied.

In this study, it is found that electrical field does not affect the photosynthesis rate of *Elodea canadensis* which means that electrical fields does not have a negative impact on the aquatic ecosystem in terms of oxygen level and primary production. However *E. canadensis* is not the only specie that is found in the first tropic level which means that electrical fields effect on the primary production cannot be properly found by only studying the *E. canadensis*. Thus in the future researches algae should also be taken into account which means that electrical fields effect on the aquatic ecosystems' oxygen level and primary production is still an open question. On the other hand for the further researches it is important to note that constant electrical field from DC current is applied to the *Elodea canadensis* which means that the results would not be the same if AC was used. Thus in order to see the effect of the electrical field strength to the photosynthesis rate of E. Canadensis broadly, the AC current should be also used.

Appendix 1:

	Dissolved Oxygen Level (mg/L) for 275(V) (DC)				
Duration(min)	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
0	4.1	3.2	4.0	3.1	3.4
2	3.2	5.7	3.3	5.6	4.9
4	3.1	3.0	3.1	3.9	3.3
6	3.5	1.0	3.5	1.3	2.6
8	3.2	2.5	3.2	2.3	3.0
10	4.1	10.0	4.1	9.9	8.9
12	3.2	6.2	3.2	4.8	5.2
14	3.6	3.0	3.5	2.8	3.2
16	2.9	0.0	2.9	-0.3	2.8
18	3.4	5.0	3.4	4.9	3.4
20	3.0	1.2	3.0	1.4	1.4
22	3.1	3.0	3.1	2.7	3.0
24	2.6	5.0	2.6	5.0	2.6
26	2.9	5.5	3.0	5.3	5.2
28	3.7	5.0	3.7	4.8	4.0
30	3.0	4.0	3.0	3.9	3.8

Table 1: shows the dissolved oxygen level released due to photosynthesis of E. canadensis when it is exposed to 275 (V) (DC) of electrical field and when the factors that may affect the rate of photosynthesis such as temperature of water , pH of water ,distance between plates and the mass of sodium bicarbonate is kept constant for the each trial . One measurement was taken per 2 minute during 30 minute period of the with data logger.

	Dissolved Oxygen Level (mg/L) for 175(V) (DC)				
Duration(min)	**Trial1**	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
0	3.0	3.5	3.5	3.0	10.6
2	3.3	5.1	5.1	3.3	6.1
4	3.1	4.0	3.1	3.1	4.6
6	3.0	10.4	3.2	3.0	6.5
8	3.5	0.2	3.0	3.5	-0.3
10	3.3	1.5	3.0	3.3	3.1
12	2.7	3.7	-0.4	2.7	-0.3
14	3.3	3.7	4.0	3.3	4.2
16	3.6	4.8	3.6	3.6	-0.3
18	2.6	2.2	2.0	2.6	-0.3
20	3.2	4.6	2.0	3.2	1.7
22	3.2	5.7	3.4	3.2	4.0
24	3.2	2.2	2.8	3.3	3.0
26	3.0	5.1	1.0	3.6	0.9
28	3.2	1.6	1.6	3.2	1.6
30	3.2	5.1	5.1	3.2	6.8

Table 2: shows the dissolved oxygen level released due to photosynthesis of E. canadensis when it is exposed to 175 (V) (DC) of electrical field and when the factors that may affect the rate of photosynthesis such as temperature of water , pH of water ,distance between plates and the mass of sodium bicarbonate is kept constant for the each trial . One measurement was taken per 2 minute during 30 minute period of the with data logger.

	Dissolved Oxygen Level (mg/L) for 75(V) (DC)				
Duration(min)	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
0	3.0	2.5	2.9	2.9	2.5
2	3.3	3.8	2.8	3.8	3.8
4	3.1	8.8	2.6	4.2	8.8
6	3.0	8.7	2.3	2.3	8.7
8	3.5	0.8	2.6	2.7	0.8
10	3.3	1.4	2.7	1.4	1.4
12	2.7	2.4	2.8	2.9	7.4
14	3.3	3.5	2.4	2.9	3.5
16	3.6	2.4	3.2	3.4	2.4
18	2.6	-0.3	2.8	2.7	-0.3
20	3.2	7.1	2.5	3.2	7.1
22	3.2	1.1	3.0	3.1	1.1
24	3.3	9.6	2.8	3.1	9.6
26	3.0	9.4	3.0	8.9	9.4
28	3.2	1.7	3.0	3.2	1.7
30	3.2	6.3	3.0	3.0	6.3

Table 3: shows the dissolved oxygen level released due to photosynthesis of E. canadensis when it is not exposed to 75 (V) (DC) of electrical field and when the factors that may affect the rate of photosynthesis such as temperature of water , pH of water ,distance between plates and the mass of sodium bicarbonate is kept constant for the each trial . One measurement was taken per 2 minute during 30 minute period of the with data logger.

	Dissolved Oxygen Level (mg/L) for the Control Group				
Duration(min)	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
0	4.2	3.8	4.0	3.9	4.0
2	4.3	4.2	4.1	4.2	4.1
4	3.1	3.2	3.7	3.8	3.2
6	3.2	3.1	4.0	3.7	3.7
8	5.3	4.9	4.9	4.8	5.1
10	5.6	5.3	4.9	5.2	5.2
12	4.3	4.2	4.8	4.7	4.6
14	5.6	5.4	5.3	5.5	5.2
16	5.0	4.8	5.3	5.1	4.9
18	5.0	5.2	5.1	5.3	5.0
20	4.6	5.1	5.3	5.3	5.1
22	3.5	4.0	4.2	3.7	3.6
24	2.9	3.0	3.2	3.5	2.8
26	4.3	3.9	3.5	4.2	4.0
28	3.0	3.4	3.8	3.0	3.6
30	4.7	4.8	4.5	4.6	5.0

Table 4: shows the dissolved oxygen level released due to photosynthesis of E. canadensis when it is not exposed to electrical field and when the factors that may affect the rate of photosynthesis such as temperature of water , pH of water ,distance between plates and the mass of sodium bicarbonate is kept constant for the each trial . One measurement was taken per 2 minute during 30 minute period of the with data logger.

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