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EXTENDED ESSAY

ENVIRONMENTAL SYSTEMS AND SOCIETIES

HOW THE INCREASING CONCENTRATIONS OF AMMONIA IONS DOES MIXED IN WATER ENVIRONMENTS BY MINING INDUSTRY WASTEWATERS, THREATES THE AQUATIC LIFE?

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1. Abstract

Environmental pollution is a big problem in today's world. Every passing year, the needs of mankind, technology and industrialization increases on high rates. This increase brings with a high amount of consumptions especially in developed countries. Iron and metal industries are also a part of this consumption. After giving shape to those metals, cooling them is the follower step. Tons of water is used for this cooling process and high amount of ammonia ions mixed in those waters. These ammonia ions can cause toxic effect for living organisms in water environments. This experiment focused on the toxic effect of ammonia ions on the *Elodea canedensis* and dealt with the research question, "How does the amount of ammonia ions mixed in environment by mining industry wastewaters effect the photosynthesis rates of *E. canedensis?* The plant used in this experiment was *Elodea canedensis.* Identical pieces of an *E. canedensis* are placed in 500 ml beaker glasses. Increasing amounts of liquid ammonia solutions are placed to five different groups and observed for 4 days. 5 trials are made for each group than the data are recorded. 2.6 ml/ 5.6 ml/ 8.6 ml/ 11.6 ml/ 14.6 ml ammonia ions are added to the beaker glasses of groups 1, 2, 3, 4, and 5 respectively. In order to observe the photosynthesis rate, *E. canedensis* plants are placed under a test tube filled with water by the help of a funnel. Oxygen gas released by photosynthesis will make a pressure in the test tubes and by this way the water level will decrease and photosynthesis levels of different groups can be observed.

. The results of this experiment supported my hypothesis that stated the increasing the ammonia ion concentration will decrease the photosynthesis level which proved the toxic effect of ammonia on aquatic environments.

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3. INTRODUCTION

Last year I have started studying the ib program in my school. When I learned that I need to write an extended essay, biology was the first subject that comes to my mind. But then some months later, when I really get into the ESS classes I decided to write my extended essay about more social issues. After some researches I decided that the waste water pollution will be the best subject for my extended essay.

From the media we all know that environmental pollution is a big issue for the future of our planet. I chose this subject to gain a deep knowledge about the environmental pollution. We all told to make recycle and not to throw trashes in the environment but we do not know the scientific reasons behind those acts.

Every passing year, the needs of mankind, technology and industrialization increases on high rates. This increase brings with a high amount of consumptions especially in developed countries.

The earth is covered by lots of resources of raw materials. Mines like iron, steel, aluminum, silver, gold etc. are used very rapidly. Nearly every device that we use in our daily lives are made up of those materials. As they are so common in daily life, people dealing with the industrial process of iron and steel, especially big corporations invest astronomic amounts moneys on that business. [1]

The mining of iron and steel are not as hard compared with silver and gold. Also the industrial process is cheaper. So the production of milled iron and steel are so high. According to the currencies of 10.9.2014, the price of 1 kg gold is 39350 dollars. But when we look at iron, its price is 0.67 dollars for 1 kg. [2]

Only in Turkey, 14 million tons of iron mined in the year 1999. [3] Mine and quarry industries has a huge impact on environment. In 21. Century we use metals and mines a lot in our daily lives. Especially iron and steel is so common. Every car we see on the streets are made up of iron and steel, every technological device we use, every building has an steel skeleton and every little cap screw made up of those materials. We use those materials a lot but we never think how those materials are produced and is there any dangerous impact on environment. [4] As we can guess, those metals don't found as proper shapes. People are shaping those metals in order to make them usable in the industries. After this heating, in order to keep the shape of the metal, they need to be cooled. In this cooling process, water is used. When heating those metals toxic material like ammonia and cyanide come out and in the cooling process those toxic materials are mixed in to the cooling waters. In order to get rid of from those dirty and toxic waters, companies prefer to throw those water in to lakes, seas and oceans. This situation cause a huge danger for the aquatic life. As aquatic organisms ca not de compose ammonia, ammonia becomes highly toxic for them and it poisonousness those organisms. 2449.16 liters of water used in the industrial progress of steel. [5] For iron this value is 1858 liters per tons of iron. [6] In this experiment we use *E. canedensis* as an aquatic organism and add different amounts of ammonia to 5 different beakers in order to observe the poisonous effect of ammonia by looking at the photosynthesis rates.

3.1 Structure of *E. canedensis*

E. canedensis is an aquatic plant often called as the North America water weeds. Elodeas are mostly used as aquarium vegetation and it lives in fresh water. It lives entirely under water and it produces winter buds from the steam tips that overwinter on the lake bottom. They reproduce in the fall and they can live in wild range from deep to shallow. Rich in nutrient sediment and fresh water needed for them to grow. They can even continue growing without attaching or binding any sediment and without roots. The American water weeds (*E. canedensis*) is an important part of America lake ecosystem. [7] It forms habitats for many aquatic invertebrates, young fishes and amphibians. Ducks, beaver, muskrat and aquatic turtles eat that plant. As they become so common in aquarium industry, in order to avoid them to extinct some states and some countries forbid sailing *E. canedensis* in pet shops.

E. canedensis starts growing in mud at the bottom of the water. It produces roots from the main stem and it lives entirely under water except the small white flowers which float at the surface and are attached to the plant by delicate stalks. It grows indefinitely at the steam tips, and single specimens may reach lengths of 3m or more. It requires summer water temperatures of 10–25 °C and moderate to bright lighting. [8]

As we all know plants produce their food and oxygen by photosynthesis. Photosynthesis is a way of producing energy from light intensity. It is done by most of the producers in a food chain and needed for continuing the environmental life. Photosynthesis is the procedure of converting carbon dioxide and water into glucose and oxygen by using sunlight. This procedure is happening in leafs of a plant. The leaf are containing chloroplast organelles. Photosynthesis is done in those organelles. The chemical energy gained from photosynthesis is stored in

carbohydrate molecules such as sugar and starch. After the photosynthesis process the oxygen is realized as waste product. Photosynthetic organisms are called as photoautotrophs. [9]

3.2 Ammonia

Ammonia is a compound formed by nitrogen and hydrogen. Its formula is NH_4^+. [10] It is found in gas form in the in the environment and it found in the urine of terrestrial organisms as a waste product. It has a highly toxic effect on plants but not highly toxic for humans and mammals. A specific mechanism exist to prevent its build-up in the bloodstream. Ammonia is converted to carbamoyl phosphate by enzymes in mammal's metabolism and then enters the urea cycle to be either incorporated into amino acids or excreted in the urine. However fishes and aquatic plants such as *E. canedensis* lack this mechanism. [11] And because of that the ammonia has a highly damage and poisonous effect on *E. canedensis* which is seen on the photosynthesis rate of it. So ammonia becomes highly toxic to aquatic environment and for this reason it is classified as dangerous for the environment.

3.3 The optimum amount of ammonia in aquatic life

EPA (United States environmental protection agency) recommends an acute criterion magnitude of 17 mg total ammonia nitrogen per liter at pH 7 and 20 °C for 1 hour average duration. For a four days period of time (the duration of experiment time) must be at most 4.48 mg ammonia per liter at 20°C and pH 7. As ammonia is highly toxic for aquatic life, EPA suggests that 4.48 mg (5.2 ml approximately) must be the highest amount of ammonia that must be an aquatic

environment should contain per liter. [12] In this experiment, we used 500 ml beakers and used 2.6 ml of ammonia in the first beaker. Then increase it by adding 3 ml more in every beaker. So we have 5 beakers containing 2.6 ml, 5.6 ml, 8.6 ml, 11.6 ml and 14.6 ml of ammonia.

4. RESEARCH QUESTION

How does the photosynthesis level of *E. canedensis* in 500 ml beaker glasses, effected by increasing ammonia ion solutions respectively 2.6ml, 5.6ml, 8.6ml, 11.6ml and 14.6 ml while the water qualities, temperature and light intensity tried to be constant for all groups?

To answer this question, the impacts of ammonia on environment must be observed. In order to do that, data for rate of photosynthesis of *E. canedensis* are needed. So that the toxic effect of ammonia on environment can be discussed.

5. HYPOTHESIS

The ammonia ions has a toxic effect on *E. canedensis* plant. Ammonia is converted to carbamoyl phosphate by enzymes in mammal's metabolism and then enters the urea cycle to be either incorporated into amino acids or excreted in the urine. However fishes and aquatic plants such as *E. canedensis* lack this mechanism. As a result it can be hypothesized that **"the increasing ammonia concentration added in 500 ml beaker glasses will decrease the photosynthesis rate of *E. canedensis*".**

Aim: investigating the effect of ammonia ions on photosynthesis rate of *E. canedensis.*

6. VARIABLES

Independent varıable

Amount of ammonia: (2.6 ml, 5.6 ml, 8.6 ml, 11.6 ml, 14.6 ml) of ammonia will be added to 5 different cups, controlled by a graduated cylinder)

Dependent variables

Rate of photosynthesis: will be measured by observing the height of water (resulting from the produced oxygen) at the test tube

Controlled variables

- Length of plants: the length of *E. canadensis* will be measured by a metric ruler with an uncertainty of 0.5 cm. All 25 pieces of *E. canadensis* must be have a length of 20.00 cm.
- Number of leaves at plants: the number of leafs at all elodeas must be stabilized by counting them by hand and we need to be make sure that all of them contains (50 ± 1) leaf number.
- Amount of water at cups: as we place *E. canadensis* at identical cups, we need to be make sure that they are containing same amount of water which is 500 ml and must be stabilized with a cylindrical measurement cup with an uncertainty of 0.5 ml
- Cup sizes: 500 ml beaker glasses
- Temperature: temperature must be stabilized by the help of a heater and check by a mercury thermometer
- Light intensity: must be controlled by using identical 100w power of white colured bulbs.
- Light angle: light angle must be fixed 90^{o} by the help of lighter.
- Content of water

Nestlé Waters North America maximum allowable compound and microorganism levels

Item	EPA* maximum allowable level	FDA maximum allowable level	Nestlé Waters maximum allowable level
Lead	0.015mg/L	0.005mg/L	<0.0005mg/L
Copper	1.3mg/L	1.0mg/L	<0.05mg/L
Trihalomethanes (trichloromethane, tribromomethane, dibromochloromethane, bromodichloromethane)	0.08mg/L	0.08mg/L	<0.0005mg/L (individual) <0.002mg/L (sum)
Bromate	0.01mg/L	0.01mg/L	Target: <0.0005mg/L
Max: <0.002mg/L			
Nitrate	10mg/L	10mg/L	<5mg/L
Arsenic	10mg/L	10mg/L	<0.0014mg/L
Perchlorate	-	-	<0.0005mg/L
Microorganisms			
Total coliform	<1 cfu/100 ml. Not more than 5% of monthly samples showing positive. No *E. Coli* or fecal coliform positive samples	<1 cfu/100ml. No sample to exceed 4 cfu/100ml and arithmetic mean of 10 samples <1 cfu/100 ml	100% of product samples negative for total coliform bacteria
Heterotrophic or total plate count	<500 cfu/ml	-	<20 cfu/100ml (product) <100 cfu/ml (source)
Pseudomonas	-	-	Absent per 100ml
Cryptosporidium	If detected, must treat down to zero	-	Absent
Giardia	If detected, must treat down to zero	-	Absent

* United States Environmental Protection Agency

mg/L = milligrams/litre; ml = millilitres; cfu = colony forming unit

(The Figure 1): shows the content of nestle pure life water that I used in the experiment. [13]

7. MATERIAL LIST

1. 25x identical 500 ml beaker glasses
2. 215 ml of ammonia
3. 5x identical table lamps
4. 5x 100W white light bulbs
5. 25x 500ml nestle pure life water
6. 1x thermometer
7. 25x test tubes
8. 25x identical funnels
9. A board marker
10. A clock
11. 1x metric ruler
12. 1x stirrer

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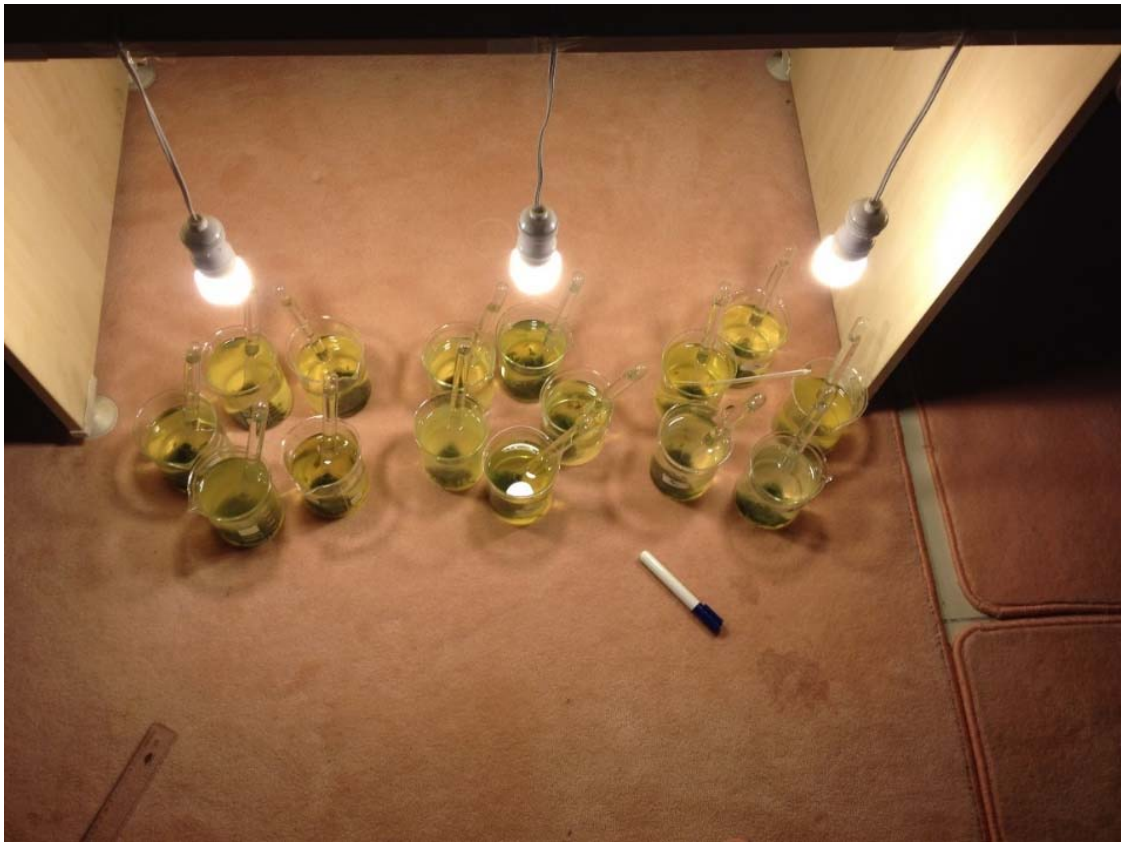

(The Figure 1.2): shows the materials and experimental contrivance

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8. METHOD DEVELOPMENT AND PLANNIG

Measuring the photosynthesis rate

There are some methods to measure the photosynthesis rate of aquatic plants. In this experiment we used the way of observing the decrease in water height in the tube. We used 1 funnel, 1 500 ml beaker and 1 test tube. We placed the *E. canedensis* inside funnel and then fill the test tube with water. Then place the funnel at the top of the test tube and place it inside the 500 ml beaker filled with water as shown in the figure. When the *E. canedensis* starts photosynthesis,

The oxygen gas realized from *E. canedensis* (as a side Product of photosynthesis) so the level of water rises.

It starts to produce oxygen as a waste product and the oxygen gas starts to move to the top of the tube from the funnel. The oxygen gas on the top of the tube makes a pressure on water and water level in the tube starts to decrease. [13] The more photosynthesis means more oxygen gas and more oxygen gas creates more pressure on the water son the water decreases. In this experiment we observed that the beaker has the highest ammonia concentration nearly doesn't decreased any water so that means it has the lowest photosynthesis rate.

(The Figure 1.3): shows the second day of the experimental period

Experimental method

1. Take a 500 ml beaker glass and fill it with 500 ml nestle pure life water.
2. Fill the test tube with 10 ml nestle pure life water and put the funnel at the top of the test tube (figure 1.3)
3. Put the *E. canedensis* water plants inside funnel which are 20 cm tall and leaf number of 50.
4. Put the funnel and test tube inside the 500 ml beaker glass filled with 500 ml nestle pure life water as shown in the figure 1.4.
5. Add 2.6 ml of ammonia inside the 500 ml beaker by using a graduated cylinder and stir the solution for a while

6. By using the thermometer measure the temperature and be sure that it is 22 °C
7. Mark the level of water inside the test tube with a board marker
8. Repeat this process from 1 to 7 for 4 more times for 2. 6 ml of ammonia.
9. Then repeat the process from 1 to 7 for 5.6 ml, 8.6 ml, 11.6 ml and 14.6 ml of ammonia.
10. Measure the decrease in water level from the marked points at the test tubes by the help of a ruler.
11. Collect data for 3 times in a day at the same time every day for 4 days of experimental process.
12. Record your data to your raw data table.

NOTES

- Be careful and quick when putting the test tubes inside the beakers.
- If you splash water when putting the test tubes, add some nestle pure life water until it fixed to 500 ml
- Ammonia has a disturbing smell, if it's possible use a mask when preparing ammonia solutions.
- Wash your hands carefully if you split ammonia to your hands.
- Mark the beakers in order not to mix when collecting data.
- Some oxygen bubbles may stack inside the funnel. Shake the tubes before collecting data in order to make those bubbles move towards the tubes.

(The Figure 1.4) shows the water levels of the 1st trial (2.6 ml liquid ammonia) in the second day of the experimental period

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9. RESULTS AND ANALYSIS

decrease in water level in tests tubes measured 3 times a day for 4 days (± 0.5 cm)

		trials	1st day			2nd day			3rd day			4th day		
			06:45	16:30	23:00	06:45	16:30	23:00	06:45	16:30	23:00	06:45	16:30	23:00
amount of ammonia added (± 0.1 ml)	1st pot 2.6 ml	1.	2	2	3	3	3	4	4	4	4	4	4	4
		2.	2	2	2	3	3	3	4	4	5	5	5	5
		3.	2	3	3	4	4	4	5	5	5	5	5	5
		4.	2	2	2	3	4	5	6	7	7	7	7	7
		5	3	4	4	4	4	4	4	5	6	6	6	6

(The Table 1) results for the 1 group (2.6 ml ammonia concentration) after 4 days of experimental period.

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decrease in water level in tests tubes measured 3 times a day for 4 days (± 0.5 cm)

		trials	1st day			2nd day			3rd day			4th day		
			06:45	16:30	23:00	06:45	16:30	23:00	06:45	16:30	23:00	06:45	16:30	23:00
amount of ammonia added (± 0.1 ml)	2nd pot 5.6 ml	1.	2	2	2	4	4	5	5	5	5	5	5	5
		2.	2	2	3	4	4	4	4	4	4	4	4	4
		3.	2	2	3	5	5	5	5	5	5	5	5	5
		4.	2	3	3	3	3	3	3	3	3	3	3	3
		5	3	3	4	4	4	5	5	5	5	5	5	5

(The table 2) results for the 2 group (5.6 ml ammonia concentration) after 4 days of experimental period.

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decrease in water level in tests tubes measured 3 times a day for 4 days (± 0.5 cm)

amount of ammonia added (± 0.1 ml)		trials	1st day			2nd day			3rd day			4th day		
			06:45	16:30	23:00	06:45	16:30	23:00	06:45	16:30	23:00	06:45	16:30	23:00
	3rd pot 8.6 ml	1	1	1	1	2	2	2	2	2	2	2	2	2
		2	0	0	0	0	1	1	1	1	1	1	1	1
		3	1	1	2	3	3	3	4	4	4	4	4	4
		4	1	1	2	2	2	3	3	3	3	3	3	3
		5	0	1	1	2	2	2	3	3	4	4	4	4

(The table 3) results for the group 3 (8.6 ml ammonia concentration) after 4 days of experimental period.

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decrease in water level in tests tubes measured 3 times a day for 4 days (± 0.5 cm)

amount of ammonia added (± 0.1 ml)		trials	1st day			2nd day			3rd day			4th day		
			06:45	16:30	23:00	06:45	16:30	23:00	06:45	16:30	23:00	06:45	16:30	23:00
	4th pot 11.6 ml	1	1	2	2	3	3	3	3	3	3	3	3	3
		2	0	0	0	1	1	1	1	1	1	1	1	1
		3	1	1	2	3	3	3	3	3	3	3	3	3
		4	0	1	1	1	1	1	1	1	1	1	1	1
		5	0	0	0	0	0	0	0	0	0	0	0	0

(The table 4) results for the group 4 (11.6 ml of ammonia concentration) after 4 days of experimental period

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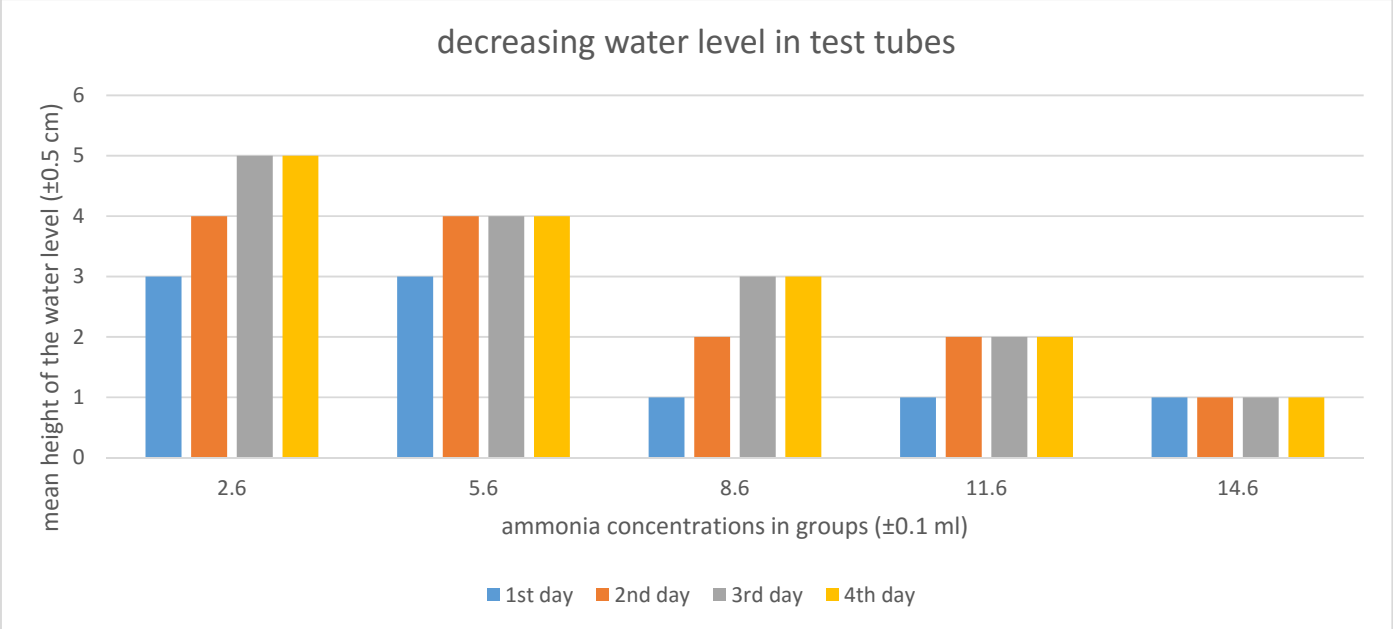
decrease in water level in tests tubes measured 3 times a day for 4 days (± 0.5 cm)

amount of ammonia added (± 0.1 ml)		trials	1st day			2nd day			3rd day			4th day		
			06:45	16:30	23:00	06:45	16:30	23:00	06:45	16:30	23:00	06:45	16:30	23:00
	5th pot 14.6 ml	1	1	1	1	2	2	3	3	3	3	3	3	3
		2	1	2	2	2	2	2	2	2	2	2	2	2
		3	0	1	1	1	1	1	1	1	1	1	1	1
		4	0	0	0	0	0	0	0	0	0	0	0	0
		5	0	0	0	1	1	1	1	1	1	1	1	1

(The table 5) results for the group 5 (14.6 ml of ammonia concentration) after 4 days of experimental period

	group 1 (2.6±0.1 ml)	group 2 (5.6±0.1 ml)	group 3 (8.6±0.1 ml)	group 4 (11.6±0.1 ml)	group 5 (14.6±0.1 ml)
1st day	3	3	1	1	1
2nd day	4	4	2	2	1
3rd day	5	4	3	2	1
4th day	5	4	3	2	1

(The table 6) mean values of every group (calculated from the data of 23:00 pm) for 4 days



(The graph 1) shows the decreasing rise in water level as the increase in ammonia concentration

Anova Calculations

Anova: Single Factor

SUMMARY

GROUPS	*COUNT*	*SUM*	*AVERAGE*	*VARIANCE*
group 1 (2.6 ml)	4	17	4,25	0,916666667
group 2 (5.6 ml)	4	15	3,75	0,25
group 3 (8.6 ml)	4	9	2,25	0,916666667
group 4 (11.6 ml)	4	7	1,75	0,25
group 5 (14.6 ml)	4	4	1	0

ANOVA

source of variation	*SS*	*Df*	*MS*	*F*	***P-value***	*F crit*
between groups	29,8	4	7,45	15,96428571	**2,77973E-05**	3,055568
within groups	7	15	0,466666667			
Total	36,8	19				

(The table 7) Anova test applied on (table 6). The results could be tested if there is a significant statistical difference between the mean of groups. It is possible to form two null- hypothesis.

H_1: different concentrations of ammonia solution will affect the photosynthesis rate of *E. canedensi.*

H_2: different concentrations of ammonia solution wouldn't have any effect on the photosynthesis rate of *E. canedensis.*

10. CONCLUSION AND EVALUATION

The aim of this project was to determine ***how does the amount of ammonia ions mixed in environment by mining industry wastewaters effect the photosynthesis rates of E. canedensis?*** It was expected that when the ammonia concentration in the experimental samples are increased, the rate of photosynthesis will decrease because of the toxic effect of ammonia on ***E. canedensis.***

In order to observe the created hypothesis, an experimental contrivance was prepared. 5 different amounts liquid ammonia which are 2.6 ml, 5.6 ml, 8.6 ml, 11.6 ml and 14.6 ml are prepared. The volumes of liquid ammonia amounts are determined considering the report as EPA (environmental protection agency). According to this information, 25 different beaker glasses filled with 500 ml water and ***E. canedensis*** are prepared for 4 days of experimental observation. For each different ammonia amount, five trials are made. For 4 days, 3 times each day data are collected and recorded. See the tables 1, 2, 3, 4 and 5 for results.

The average rise in water levels in test were found 4.25 cm, 3.75 cm, 2.75 cm, 1.75 cm and 1 cm for groups 1, 2, 3, and 5 respectively. See the graph 1 to observe the rise in water level distributions for 4 days. There is a clear decrease in water level height change against the increasing ammonia concentration.

See table 7, Anova test is applied to prove the statistic relation between the water level height change and ammonia concentration. This evaluation is done by checking the P- value. It is possible the see the P- value at table 7 (marked with bold).

X = 0.5 > p value = 2.77973E-05

The P- value is smaller than 0.05 indicates that statistical mean difference between groups. As a result. As a result, H_1: "different concentrations of ammonia solution will affect the photosynthesis rate of *E. canedensi".* Hypothesis is proved and H_2: "different concentrations of ammonia solution wouldn't have any effect on the photosynthesis rate of *E. canedensis".* Is declined.

This ammonia emission from mining industries creates a big danger for the aquatic life. When the photosynthesis rate of photosynthetic organisms decreases in aquatic environments, the amount of dissolved oxygen in water decreases and this kills fishes in the lakes and oceans. It is not only poisons the ***E. canedensis*** but also harmful for all living organisms in aquatic environment. This situation may cause some species to extinct and effects the environmental diversity if we think on the basic stage. Besides the environmental effects, this water treatment has economic and social impacts too. If the water treatments are not controlled in industries it will harm the aquatic environments which may decrease the number and diversity of aquatic organisms especially fishes, lobsters and clams which we ate in the restaurants will be more expensive or even the worst maybe there won't be any fishes to eat in next 50 years. Another example can be the drinking waters, those waste waters can mix in the watercourses that we use for fresh water and that may cause illnesses in the society.

There are some ways which can improve the experimental method and by this way the results will be more trustable. First of all the experiment can be done in a more isolated place then the basement of my house. In order to arrange the day light and night periods, a place which has no light entrance will be better. Secondly, the length, leaf size, and leaf number of ***E. canedensis*** must be controlled better. Especially the leaf number plays an important role on photosynthesis. Also you need to use a lot of ***E. canedensis*** in order to observe the photosynthesis level in the water tube because poor amount of ***E. canedensis*** makes no change in the water level of the water tube. If possible, try to use an oxygen prob which measures the rate of photosynthesis digitally. By this way your results will be more realistic and will be more economic because ***E. canedensis*** is a rare and expensive plant. You may have difficulties when finding it. If you are going to use the water tube method, use a measuring tape because it's hard to measure the changing water level with a solid meter. Also the liquid ammonia has a redolent smell so use a mask when working with the ammonia if it is possible.

To conclude, in this project I investigated the effect of waste water treatments on environment. Every passing year mankind becomes more selfish. We use all the environmental sources without thinking sustainability and without thinking the future. We always harm the environment for our gains and for the money. This project and especially the ess classes helped me to gain a knowledge about all those environmental and social issues. I hope my project reflects the things I have learned.

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