Impacts of Climate Change Induced Salinity Intrusion on Physiological Parameters of Some Aquatic Hydrophytes

ASIAN UNIVERSITY FOR WOMEN

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Abstract:

Changing temperature, precipitation regimes, sea-level rise- all of these are associated with the global phenomenon; climate change. An inevitable consequence of this global phenomenon is salinity intrusion which is the gradual movement of salinity into groundwater as well as surface water. This salinity intrusion can have detrimental impacts on the hydrophytes or the plants living in these water sources. This experiment was conducted to see the varying impacts on the physiological traits of Water Hyacinth (*Eichhornia crassipes*), Helencha (*Enhydra Fluctuans*) , Taro (*Colocasia esculenta*) against different salinity concentrations (0 ppt , 10 ppt, 20 ppt, 30 ppt) after 48 hours due to increasing salinity as well as their physical adaptations. The physiological parameters that were measured in this experiment were Biomass, Height , Stomatal density, Transpiration rate, Total Chlorophyll Content and Relative water content. A prominent reduction in biomass and height was noticed with increasing salinity. For stomatal density it was established that the number of stomata per millimeters square decreased with the increase in salinity concentration. Result for transpiration rate was also in compliance with the result of stomatal density. As *Colocasia esculenta* was observed to be salt tolerant to some extent and had a stomatal density of 6 mm^{-2} at 30 ppt it had the capacity to transpire after 48 hours whereas the rest of the two plants did not have any open stomata at 30 ppt. Hence there was no transpiration in *Eichhornia crassipes* and *Enhydra Fluctuans* after 48 hours. Chlorophyll content was also found to be decreasing in *Eichhornia crassipes* and *Enhydra Fluctuans* but increasing in *Colocasia esculenta* with the increasing salinity concentration. RWC decreased substantially for all the hydrophytes with increasing salinity concentration after 48 hours. All the plants upon prolonged exposure did not survive and the physiological alteration observed and measured after 48 hours justified these conclusions.

Key Words; Hydrophytes, Salinity Intrusion, Climate change, Physiological parameters

Introduction:

Atmospheric concentrations of carbon dioxide have increased by 25% since the industrial revolution due to widespread deforestation and fossil fuel combustion. (Short and Hilary) Deforestation and fossil fuel combustion have increased the concentration of carbon dioxide along with other gases such as nitrous oxide, methane, chlorofluorocarbons (CFCs) which are responsible for absorbing thermal radiation from the surface of the earth and radiating it back to the earth. Due to a significant increase of these radioactive gases, an alarming elevation of Earth's surface temperature has emerged and this constant thermal expansion is predicted to melt the polar ice cap resulting in the expansion of sea level (Short and Hilary). Increasing livestock farming, fertilizers containing nitrogen produce nitrous oxide emissions, burning coal, oil and gas, variations in the sun's energy reaching Earth etc has accelerated climate change over the years. Climate change, the global threat has been observed to have effect on the large-scale hydrological cycle such as: increasing atmospheric water vapor content; changing precipitation patterns and intensity, reduced snow cover and widespread melting of ice (Short and Hilary) . One of the impacts of this drastic change is the increased rate of salinity. Sea level rise due to climate change will cause saline water to migrate to upstream points where only fresh water was existent. Researchers have predicted the increase in salinity concentration in estuaries and change in their circulation due to sea level rise (Short and Hilary). These alterations will eventually result in adverse effects on salt-sensitive habitats. Hydrophytes or plants that grow in water have a moderate range of salinity tolerance beyond which their survival becomes crucial as excessive saline stress impairs their physiological as well as biochemical processes. Research works have confirmed substantial change in physiological traits of hydrophytes due to saline stress. For example, salinity reduces CO_2 availability in plants that is a result of diffusion limitation which leads to a reduction of the photosynthetic pigments. Machado et al. reports that excessive salt concentration leads to salt accumulation which also reduces chlorophyll content and affects the light absorbance by plants (Machado et al). Growth and survival of hydrophytes is essential for the regulation of native habitats in fresh water. Substantial ecosystem services such as habitat for aquatic animals, nutrient cycling, and preservation of water quality, production of wave energy and absorption of wave energy etc substantial ecosystem services are dependent upon hydrophytes. Hydrophytes are indispensable not only for their ecological importance but also for their economic significance as they aid is sustaining fisheries as well as water supply. Thus assessment and quantification of the magnitude to which these hydrophytes can survive and maintain growth is essential along with their physiological responses to varying salinity concentration. Usually the physiological response of different plants varies due to diverse physiological adaptations. Therefore in this experiment three hydrophytes Water Hyacinth (Eichhornia crassipes), Helencha (Enhydra Fluctuans) , Taro (Colocasia esculenta) were used as sample to assess the varying effects of different saline stress after specific treatment period.

Objective:

- Observing and analyzing physiological parameters (ie- Biomass yield production, Change in growth, Stomatal density, Transpiration rate, Total chlorophyll content, Relative water content) of Water Hyacinth (Eichhornia crassipes), Helencha (Enhydra Fluctuans) , Taro (Colocasia esculenta) against increasing salinity concentration of 0 ppt, 10 ppt, 20 ppt and 30 ppt.

Literature review:

Conducted studies have manifested the effects of salinity on freshwater plants in terms of their physiology and these alterations have been restrained by different physiological parameters essentially - biomass, height, transpiration rate, stomatal density, chlorophyll content, relative water content. Two foremost phenomena are responsible for the acceleration of sea level rise which is the dire consequence of climate change and they are - an acceleration of polar ice cap melting and a thermal expansion of ocean water. Intergovernmental Panel on Climate Change proclaimed a global sea level rise of 10±25 cm over the last 100 years. This rise in sea level not only prompted the elevation of the mean level of the ocean but also increased the tidal variation and this interaction depend on local geomorphology (Pugh). Tidal range as well as tidal height will have effects on current velocities, available light depth and most importantly on salinity. Penetration of salt water in the inland and upstream tidal system is a plausible consequence of this phenomenon which will eventually make estuarine environments subjected to increased mean salinity as well as peaks of salinity pulses (Pugh). Drastic alteration in salinity level of water will have impact on all physiological aspects of aquatic plants. For example, the salinity of seawater will be affected by freshwater runoff and climate change plays the significant role here. Climate change can affect these variables by altering precipitations and drain into the coastal zone that eventually leads to affect coastal water plants. Freshwater plants are not left unaffected either. Study done on Eichhornia crassipes to see the effect on the plant upon exposure to salinity suggests that high salinity severely affects plant growth and productivity (Hu et al, 211-218). Corresponding to this denouement, "Effects of Salinity on Growth of Several Aquatic Macrophytes" reports the decrease in the total dry weight of *Myriophyllun brasiliense* when they were subjected to varying salinity stress. The finding concluded the theory of plants metabolism being affected gradually until the level of salinity reached toxicity level. NaCl stresses the plants homeostasis capability by getting dissolved in water. Separated sodium ion reach the leaves of the plant and cause marginal leaf scorch when in toxic level and chloride ion gets readily absorbed as well as accumulated in the roots causing substantial damage to the mass and growth of the plants. Bernardo et al. concluded from their experiment where they observed the reduction in plant height with shoot dry weight in response to increasing salinity- induced stress in *Vigna unguiculata (L.) Walp.* The perturbs the growth of the plants under salinity treatment is the effect of NaCl on the permeability of the plasma membrane in addition with an increase of external ions as well as efflux of cytosolic solutes in plant cells (Allen et al). Another plausible reason for the reduction in plant growth is the hardening of the cell wall caused by the increased NaCl level that inhibits formative growth. It also causes reduction in plants height by decreasing water conductance of the plasma membrane. The photosynthesis function of a plant can be notably indicated by the chlorophyll contents of a plant and under adverse circumstances such as salinity, the impacts on chlorophyll have been significant. Different consequences against different salinity in terms of total chlorophyll content have been recorded as the plants physiological metabolism may vary from species to species. Alam et al. reports in their research that with increased salinity levels chlorophyll content decreased significantly in *Portulaca oleracea L.* In the research it has been propounded that enzymatic chlorophyll degradation is the result of aggravated salt stress. Burning of leaves due to high salinity level also causes degradation of pigments (Alam et al.) However, other instances where chlorophyll content increased with the increased level of salinity have also been ascertained by researchers. In such cases plants are mostly salt tolerant and they can adapt to deterotory salt stress. The authors of

"Effect of salinity on biomass yield and physiological and stem-root anatomical characteristics of purslane (Portulaca oleracea L.) accessions." excerpted a finding on *Brassica napus* that showed significant increase in chlorophyll content with an increase in salinity level. Another effect for salinity level stress is change in the number of open stomata. Stomata are microscopic pores found in epidermal tissue of leaves and each stoma is bounded by 2 crescent shaped guard cells through which transpired water escapes. These estimates can be modulated sensitively pursuant to water balance and photosynthesis. The leaf resistance is minimum when the stomata are fully open and they are maximum or near to infinite when the stomata are closed. Osmotic stress and ion toxicity are the problems stemming from salt stress and the resulting decrease in chemical activity causes cells to lose turgor. Stomatal density eminently affects the transpiration rate of the plant which perpetuates the osmotic concentration of the plants. Remote alteration in the osmotic concentration from the standard level of osmotic concentration disrupts the physiological process of the plant which eventually disturbs the growth and development of the plant. It has been viewed commonly that the transpiration exhibits impacts due to salinity stress although whether it is inhibitory or stimulatory has been disputed. While there are investigations that observed 50% increase in transpiration due to salinity stress, Alam et al observed a significant reduction in transpiration rate due to elevated salinity stress in *Portulaca oleracea L.* Similar NaCl stress induced significant reduction in transpiration rate in plants have been proclaimed by Jamil and Rha (Alam et al). In order to avoid taking up minerals dissolved in the medium the plants dissolute the sap for which plant cells cause electrolysis resulting into colloidal alteration. As a result of this, the passage of water through plasma and cell wall is resisted. This is a reason for significant water loss in plants as well. The most appropriate measure of water used by plants in terms of the physiological changes of cellular water deficit is Relative Water Content. Water potential represents the amount of water transport in the atmosphere-plant-soil continuum. RWC has been extensively described in literatures as the water status of a shoot relative to its fully hydrated state. Upon salinity treatment plants alter their osmotic potential in order to maintain turgor pressure. This adjustment is important and physiologically relevant. Morphological changes have also been recorded by several researchers to observe the effect of salinity on plants. This experiment will concentrate on three plants in terms of their physiological alteration due to salinity stress.

Methodology:

Experimental setup:

The plants were collected from different water bodies and were then kept in a setup organized at the rooftop of Asian university for women to observe their physiological changes due to different salinity concentration. The plants that were subjected to salinity were Water Hyacinth (Eichhornia crassipes), Helencha (Enhydra Fluctuans) , Taro (Colocasia esculenta). Before the plants were settled in the bowls in different salinity concentration their roots were gently dried with tissue paper and then the weight and the height of the plants were measured and recorded for further comparison and assessment. The plants were then conserved in concentration of 0, 10, 20, 30 ppt of salinity in 6 litres of water. Each species was labeled and

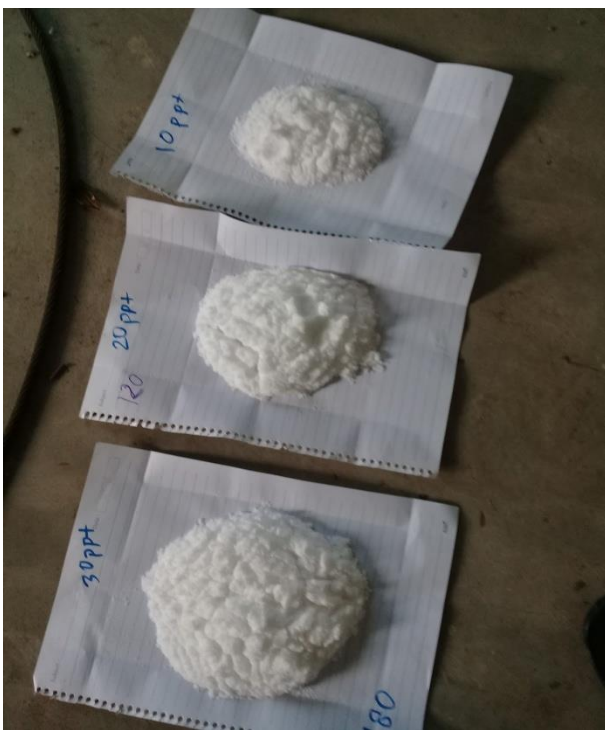


Image 1.1 :Measured NaCl for treatment

Image 1.2 : Water hyacinth in treatment

Image 1.3: Plants in treatment *Image1.4: Cork sheet used for stability*

were replicated in same concentration for accuracy. For support , cork sheet and plastic cups were used. For salinity concentration, 99% NaCl was used. Plants were kept in treatment for 48 hours. They were be subjected to four different levels of salinity (0, 10, 20, and 30 ppt). Upon 48 hours of treatment the plants were taken into laboratory for measuring several physiological parameters.

Biomass of the Plants:

Measuring biomass prior and subsequent treatment generates the overview of the effect of salinity on biomass yield production plants. In concurrence with several research articles, Alam et al. suggests the reduction of fresh biomass production due to high salinity stress caused detrimental effects. Weighing machine was balanced prior to measuring the mass of the plants. Plants were dried with tissue to avoid error. Upon measurement of weight the plants were kept in treatment for 48 hours and then mass of the plants were again recorded.

Height of the plants:

As plant growth is related to osmotic potential, osmotic effects predominate in terms of varying concentration of salinities and it has been concluded by Eaton that after salination a short time adjustment of osmotic pressure develops which is mediated by cellular potassium and organic acid concentration. If there is under adjustment of this osmotic pressure and growth depends on turgor pressure; turgor pressure will decrease and so will the growth of the plants. In furtherance of quantifying and assessing the growth of the plant in terms of height measuring tape was used to determine the height of the plants before and after salinity exposure.

Stomatal Density :

Pores that are formed with two guard cells that are associated with osmotic changes as well as transpiration and are found in the upper surface of the leaves are called stomata. Stomatal density refers to the number of stomata per area. In this experiment in order to measure stomatal density leaves from each plants from the treatment were collected and the imprint of their upper surface was made.

Image 2.1 :Leaves imprints created by clear nail varnish

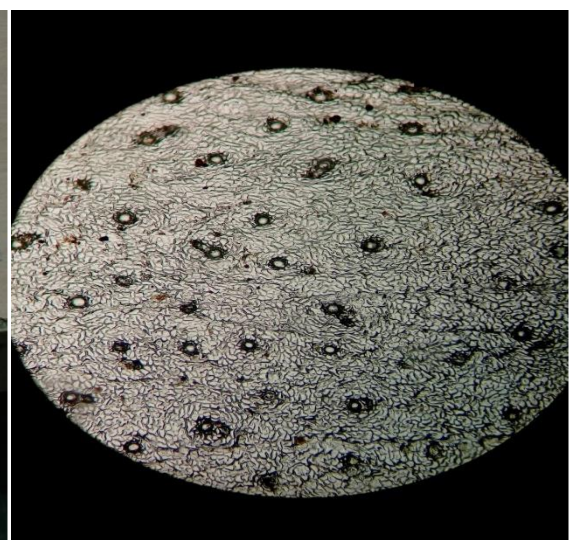


Image 2.2: Leaf imprints view under microscope

A thin layer of clear nail varnish was used to coat the surface of the leaves and later they were removed with scotch tape by peeling them off . The tape with the leaf impression was then placed on microscope slides (Heidari et al.). The slides were labeled and the excess sticky tape was trimmed using a razor blade. Then the slides were viewed under microscope at 400x magnification and the radius of the field of view was also measured which was 2 mm. The equation that was followed for measuring stomatal density is described below:

Number of stomata per field of view/ $\pi r2$; r = 2 mm

Transpiration Rate of the Plants:

Transpiration rate gives an overview of the accurate quantification of the movement of water into plants that helps in assessing the effect of different environmental stresses such as salinity to administer essential understanding of plant adaptation and alteration. In this experiment 4 similar cuttings with several leaves from each plant were put water in 12 measuring cylinders. The water level was adjusted using a teat pipette and the volume of the water was noted. 2 ml of oil was added to the measuring cylinders using a second pipette so that the oil sat on the surface level of the water. The water that was lost through the next 72 hours was recorded

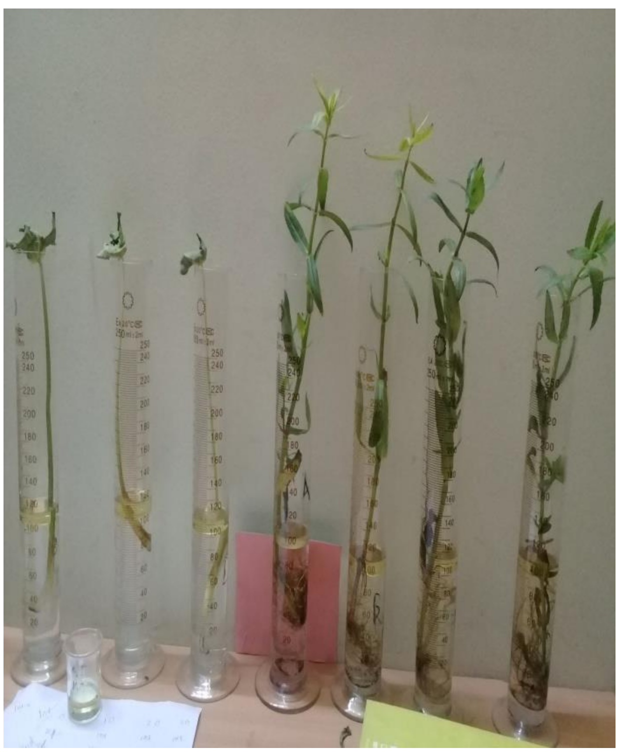


Image 3.1: Measuring cylinders to quantify transpiration rate

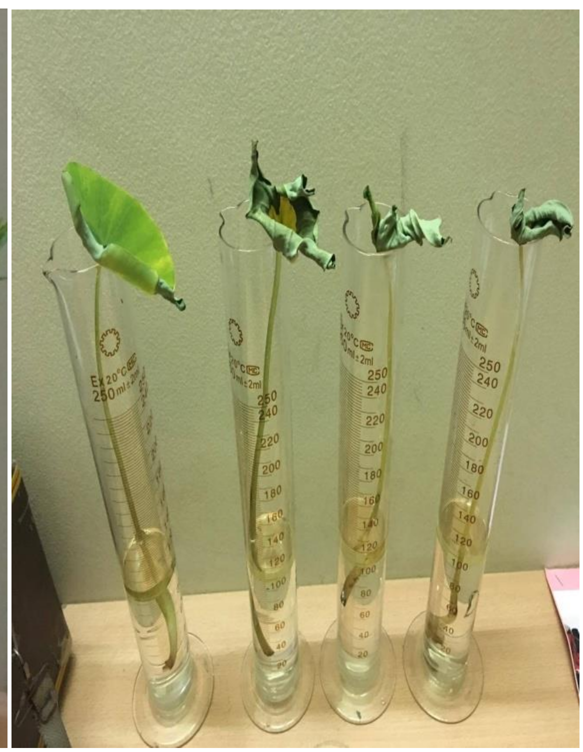


Image 3.2: Transpiration rate being measured under fluorescent light

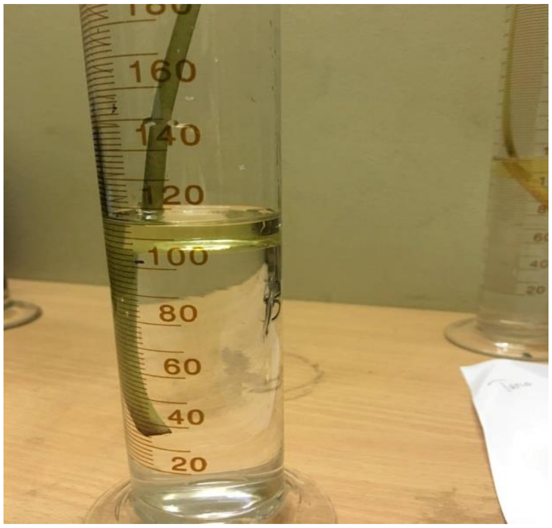


Image 3.3: Water level under the coating of oil level

in a 24 hour interval period ("Estimating Rate Of Transpiration From A Plant Cutting | Nuffield Foundation"). Transpiration rate was measured using the equation below :

Transpiration rate= (Final level of water in the cylinder- Initial level of water in the cylinder)/ 24 hour.

Constant lighting from fluorescent tube light was maintained.

Total Chlorophyll Content:

.3 g of fresh leaves were taken and ground with 9 ml of 80% acetone in test tubes for each plants from all the treatments. The test tubes were then made airtight and kept in the refrigerator overnight. It was then centrifuged at 5000 rpm for 10 mins. The supernatant was transferred into eppendorf and the absorbance of the solution was read at 645nm and 663nm against acetone using a spectrophotometer. The formula by Arnon was used for chlorophyll estimation. (K. and Banu)

Image 4.1 : Eppendorf carrying acetone prior to centrifuging

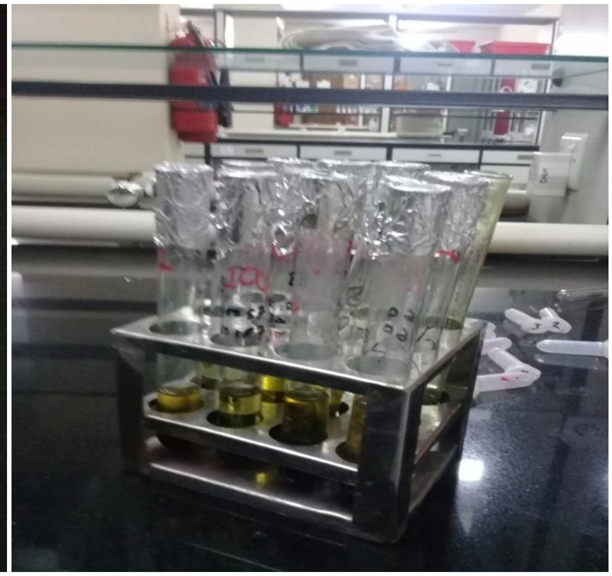


Image 4.2: Chlorophyll content in 80% acetone stored in test tubes

The concentrations of chlorophyll a, chlorophyll b and total chlorophyll were calculated using the following equation:

Total Chlorophyll: 20.2(A645) + 8.02(A663)

Chlorophyll a: 12.7(A663) – 2.69(A645)

Chlorophyll b: 22.9(A645) – 4.68(A663) (K and Banu)

Relative Water Content:

For the relative water content leaves from each plants were collected and the weight of the leaves were measured using a weighing machine. Fully expanded and mature leaves were selected to measure this parameter and the leaves were cut leaving around 1 cm long petiole. This weight was regarded as the fresh mass of the leaves. Following the measurement of the weight of the leaves the leaves were placed in a zip lock bag. In order to measure the turgor weight of the leaves 2 ml of 5mM $CaCl_2$ was inserted into the zip bag while the petiole was facing down and only the petiole was in contact with the 5mM $CaCl_2$ solution. The zip lock bag was then closed and the bag was kept in a dark in room temperature. Eight hour after the preservation of the leaves, they were taken out of the bag and put in between two paper towel in order to absorb excess water. The weight of the leaves was measured again which was the turgid weight. Consequently each leaf sample was inserted into a paper bag to be dried at 60°C for 3 days.

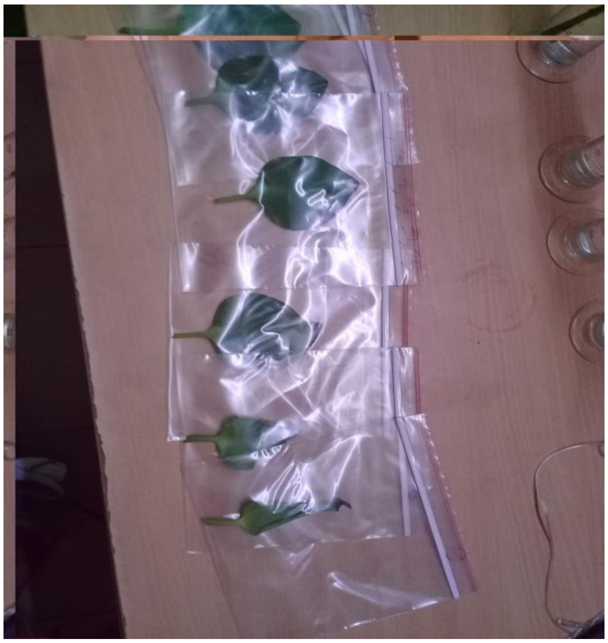


Image 5.1 *Image 5.2*

Image 5 : Image 5.1 illustrates the leaves in the ziplock bags prior to inserting 5 mM CaCl2 and 5.2 illustrates that only the petiole of the leaf being touched by CaCl2 prior to preservation in the dark

The dried weight of the leaves determined the dry weight and the relative water content of the leaf were measured using the following formula.

RWC= 100x (fresh mass- dry mass)/ (turgid mass- dry mass) (Peñuelas and Inoue, 355-360)

Result:

Biomass Reduction :

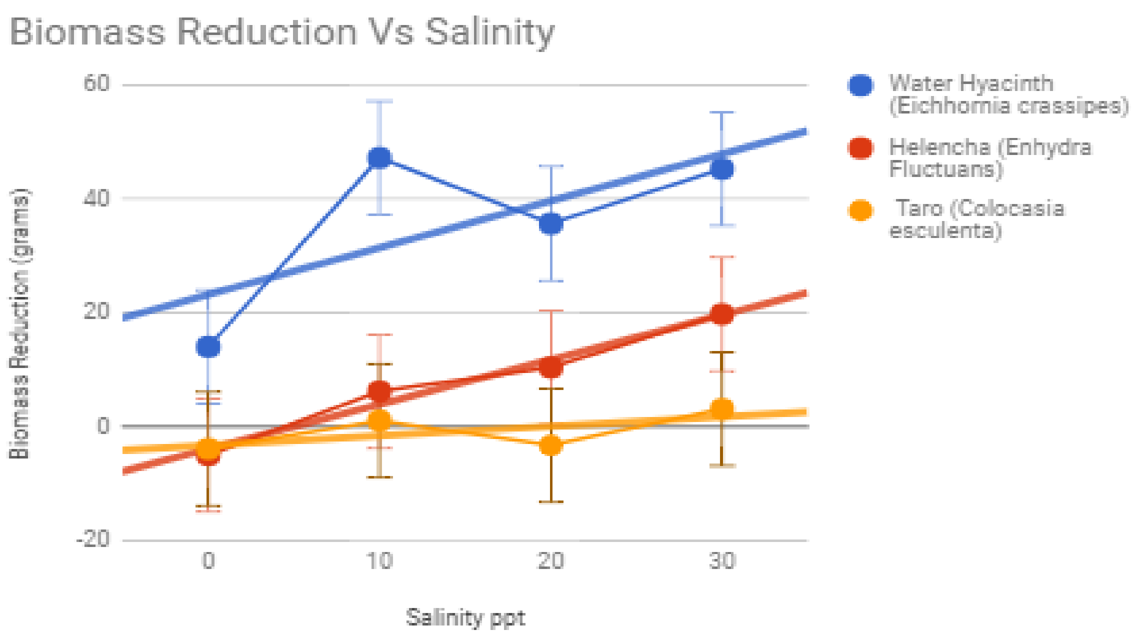


Figure 1.1 : Biomass Reduction vs Salinity

The general trend line indicates proportionality in between biomass reduction and increased salinity concentration for other plants as well. For example in terms of *Eichhornia crassip* the mean amount of biomass loss at 20ppt is 11.90 gram and when it is 30 ppt the biomass reduces to 15.37 gram .

Reduction in Plant Growth:

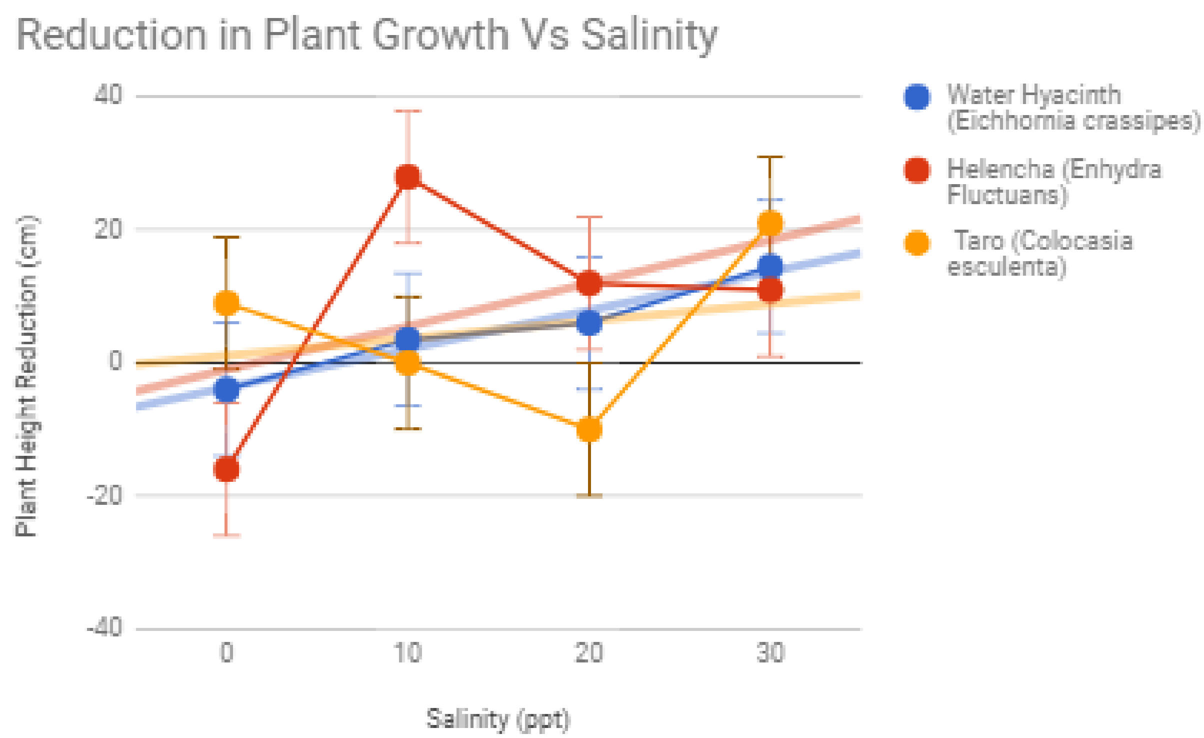
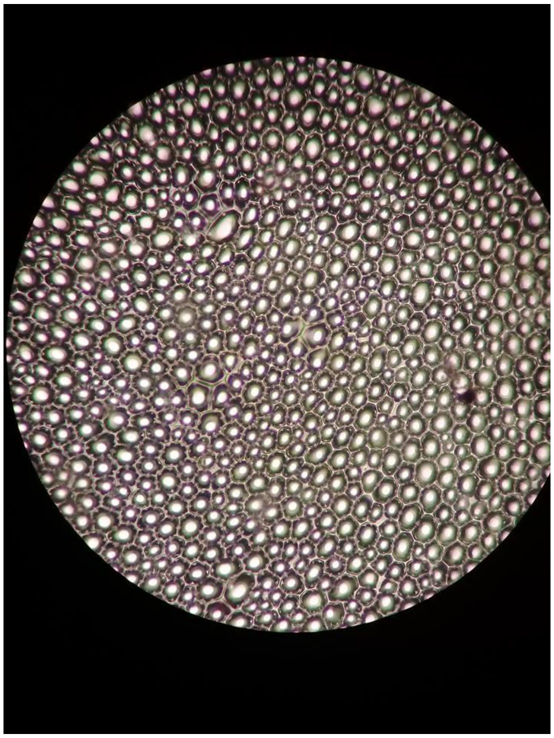


Figure 2.1: Reduction in Plant Growth Vs Salinity

The graph indicates the increase in reduction as the concentration of salinity increases. The highest reduction due to increased salinity was observed for the highest salinity concentration 30 ppt.

Stomatal density :



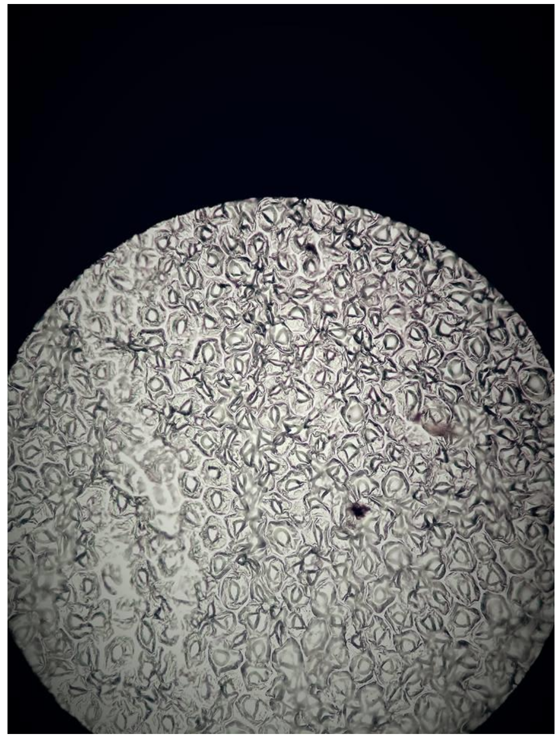
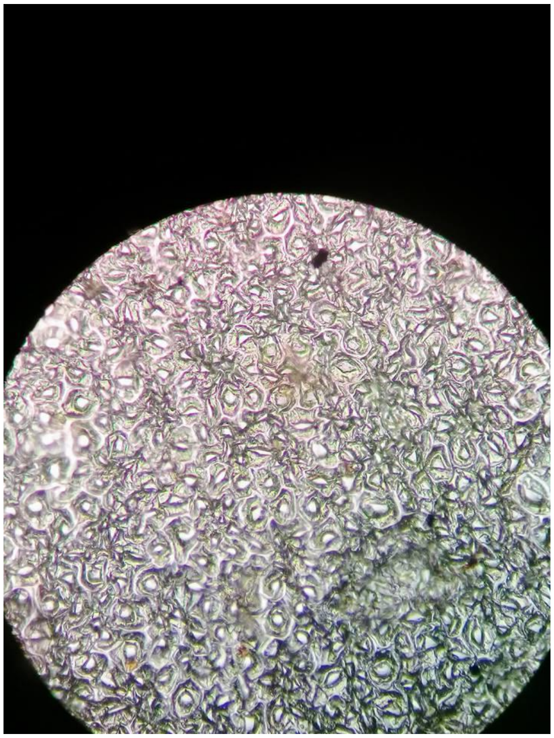


Image: 6.1 Colocasia esculenta (0ppt) ***Image 6.2 :Colocasia esculenta (10 ppt)***



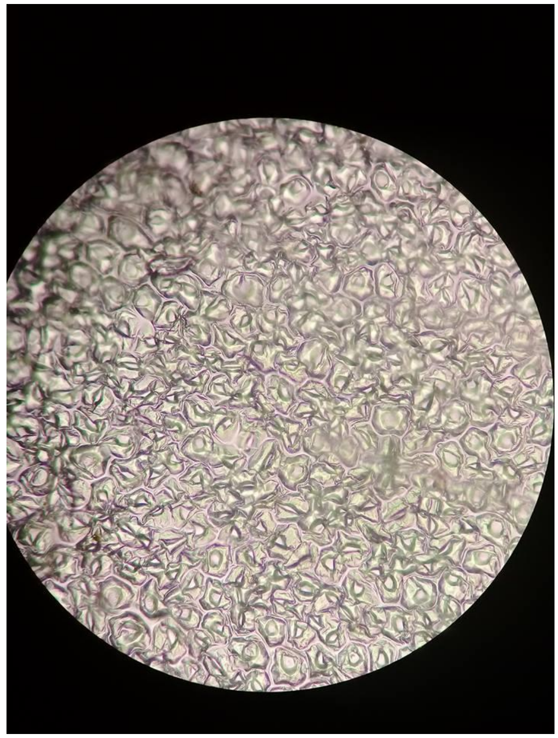


Image 6.3 :Colocasia esculenta (20ppt) *Image 6.4: Colocasia esculenta (30 ppt)*

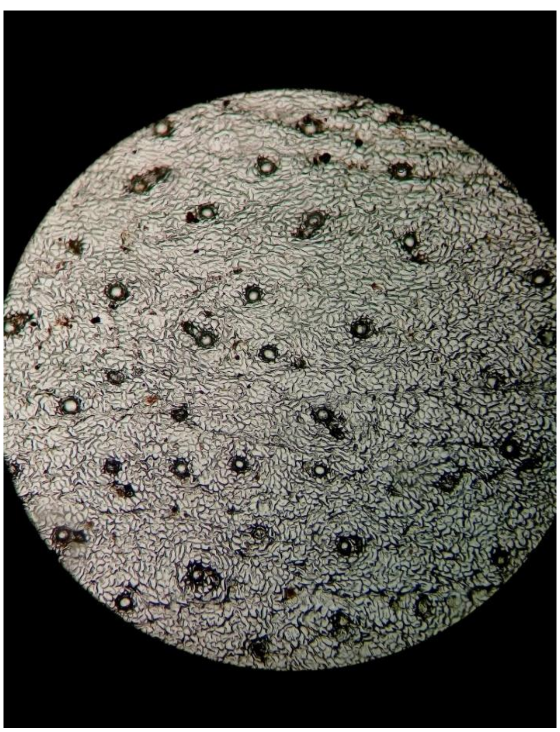


Image 6.5 Enhydra Fluctuans (0ppt) *Image 6.6 Enhydra Fluctuans (10ppt)*

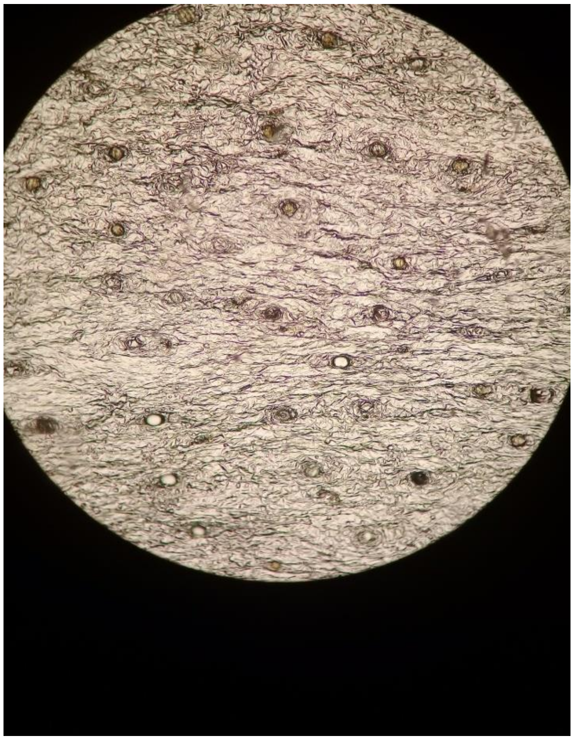
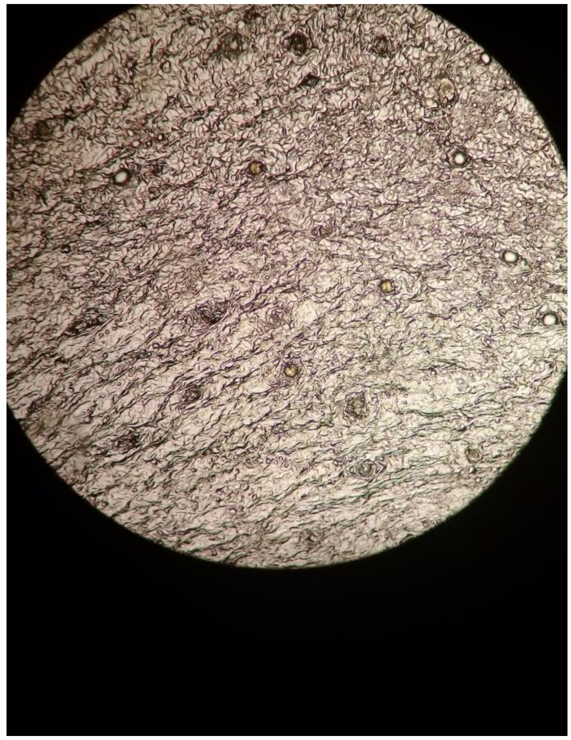
 

Image 6.7 Enhydra Fluctuans (20ppt) *Image 6.8 Enhydra Fluctuans(30ppt)*

Image 6: Microscopic view of Stomatal density of Enhydra Fluctuans and Colocasia esculenta at 400x magnification

Graph for Stomatal Density:

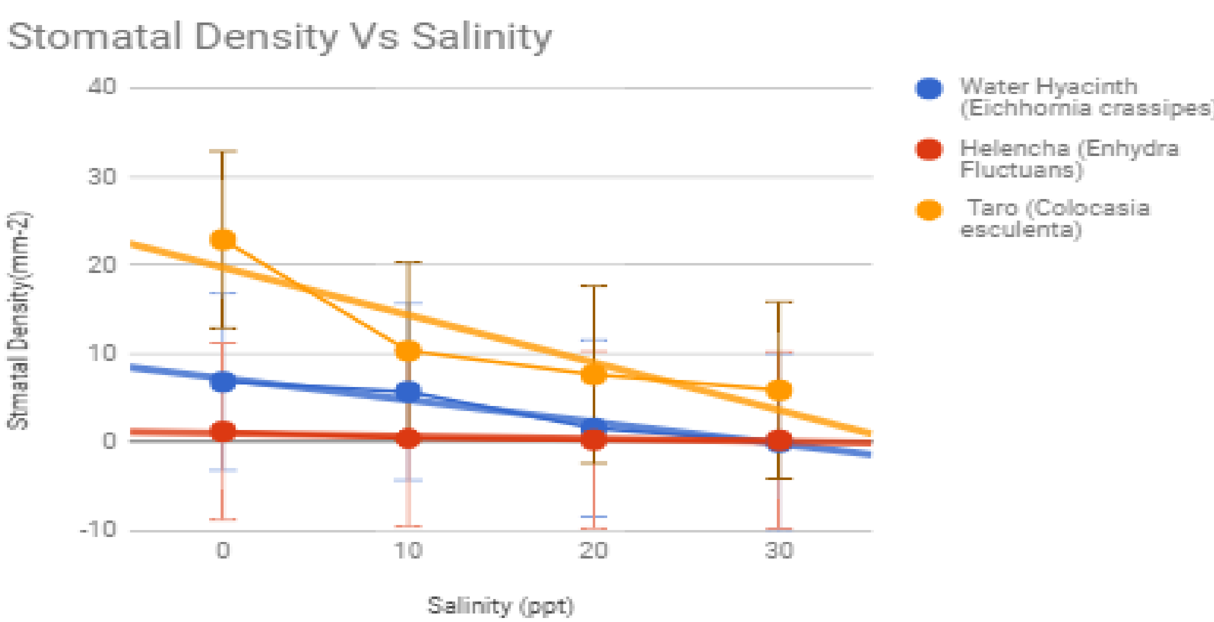


Figure 3.1 :Stomatal density(mm^{-2}) Vs Salinity Concentration (ppt)

The general trend refers to the reduction of number of stomata in 1 mm^{-2} due to increasing salinity. The highest number of stomata per mm^{-2} was observed in 0 ppt for Taro and the lowest number of stomata per mm^{-2} was noticed in Water hyacinth at 30 ppt salinity.

Transpiration Rate:

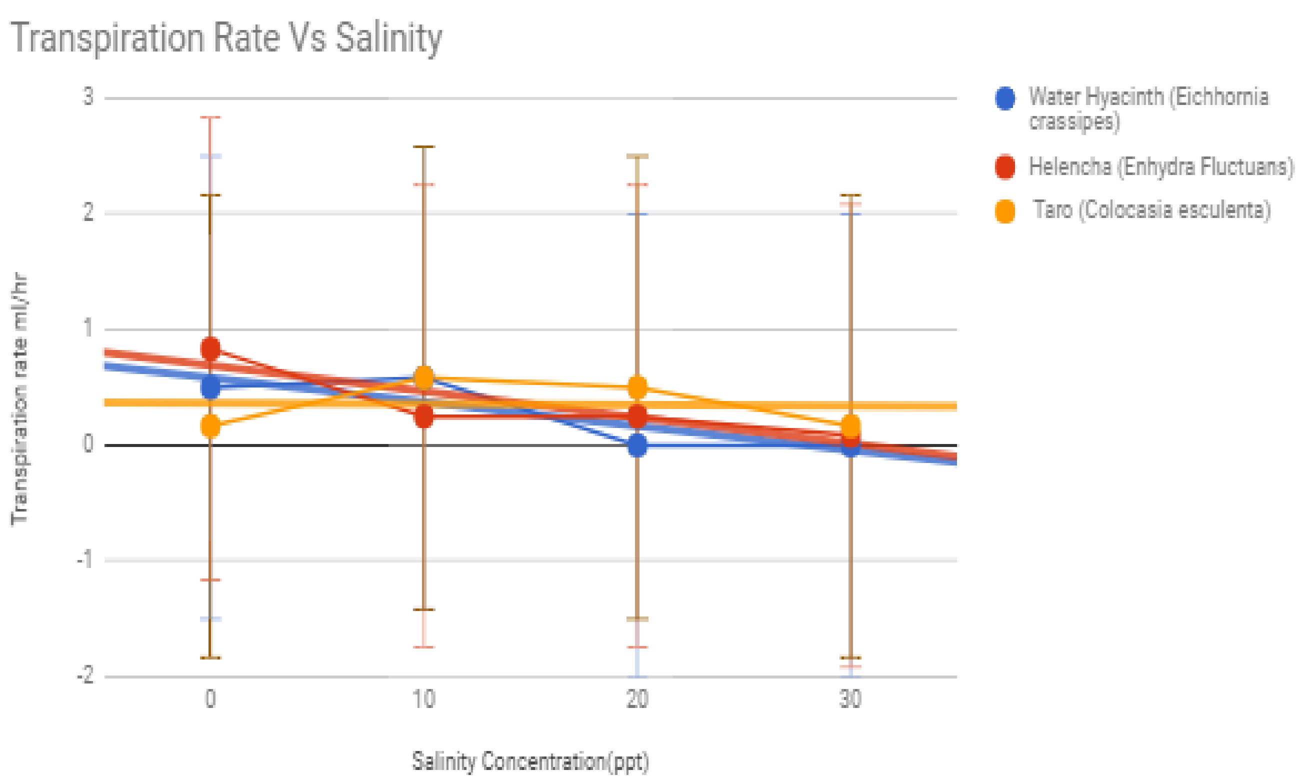


Figure 4.1: Transpiration rate Vs Salinity

In this figure the negative linear correlation expresses the decrease in transpiration rate due to the increase in salinity concentration. For *Colocasia esculenta* the transpiration rate is relatively higher than Water Hyainth and Helencha. The highest transpiration rate was found .04166 ml/hour in 0 ppt salinity for Taro and Helencha and the lowest rate 0 ml/hr was found in Water hyacinth and Taro.

Total Chlorophyll Content:

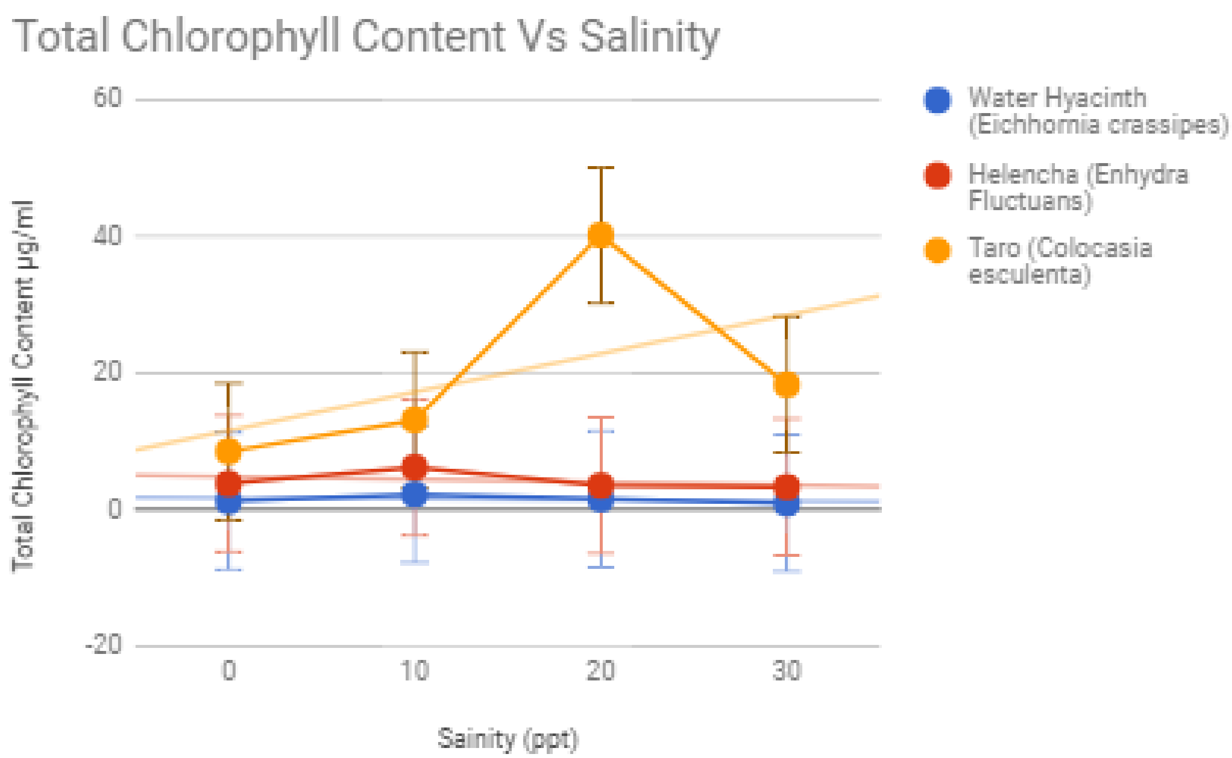


Figure 5.1: Total chlorophyll content vs Salinity

The figure shows correlation between total chlorophyll content and salinity concentration. The highest average salinity concentration was observed for Taro which was 22.22 µg/ml at 30 ppt and lowest average concentration was found 1.11 µg/ml in Water hyacinth at 30 ppt .

Relative Water Content:

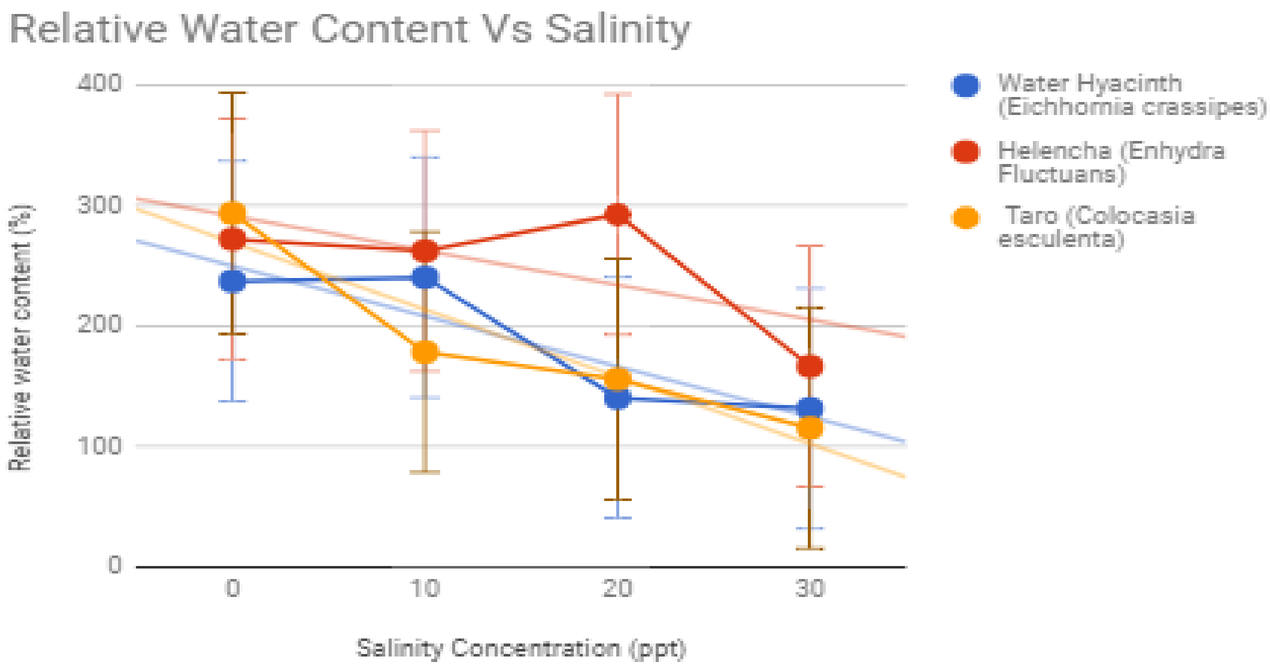


Figure 6.1: Relative Water Content Vs Salinity Concentration

In this graph it is evident that RWC decreases significantly with the increase of salinity concentration. The highest average RWC was observed in 0 ppt salinity which was 97.99% in Taro and the lowest average RWC was observed in Taro which was 37.48%.

Discussion:

The observed plants showed significant alteration in their physiological characteristics according to different levels of salinity. This result has been in compliance with other researchers' conclusions who have described the hyperosmotic and hyperionic as the reason for plants death due to high salinity. The impacts on different parameters have been described below.

Effect on Biomass:

In terms of biomass it was observed that upon exposure, the biomass for the plants decreased in treatment plants rather than in control which was 0 ppt. By observing the weight of the plants under salt stress after the treatment interval, it was noticed that a general trend appeared for the decrease in weight of the plants against increasing salinity concentration. The graph 1.1 indicates a positive linear relationship between biomass reduction and salinity concentration. The results found in this study is in agreement with the results found in an experiment by Ambede et al where the decrease in plant biomass was recorded with the increase in salinity concentration *Vigna subterranea (L.) Verdc(*Ambede et al.). The highest reduction was seen in 30 ppt for Water Hyacinth and Helencha with a mean reduction of 15.11 grams and 6.6 grams respectively. This reduction can be a plausible result of a combination of specific ion of Na+ and Cl- and increased osmotic pressure. The high salinity concentration reduced the water acquisition capability of plants which induced metabolic changes to the treatment plants. Increased osmotic pressure induces reduction in cytoplasmic volume which initiates the loss of cell turgor. Other research works have also observed opposite results where biomass increased with increased salinity. In *Colocasia esculenta* the reduction in growth was lowest and the average mass reduction that occurred in this plant at highest salinity stress was 1.03 grams. This is an indication of Taro's high salt tolerance capacity than the two other plants. Other research works have also supported Taro being salt tolerant to permissible level. ("Salt Tolerant Taro Varieties Identified In Palau")

Effect on Plant Growth:

The effect of increased salinity concentration can be seen from the linear positive relation from graph 2.1. For all three plants Water Hyacinth (Eichhornia crassipes), Helencha (Enhydra Fluctuans) and Taro (Colocasia esculenta) the reduction in height was increased in terms of increasing salinity concentration which is in agreement with other research works that have been conducted in this regard. From the graph 2.1 it can be seen that the rate of loss in reduction was highest in 30 ppt which is the highest salinity concentration. The lowest loss in reduction was observed in Taro as it has been mentioned earlier that this plant has salt tolerant capacity among the three plants and thus has been affected less in terms of the two other plants. Plant growth has been reported to be affected by salinity due to nutritional imbalances as well as specific ion toxicities. This reduction has been described to happen in two stages by Munns et al. The first stage includes water deficit induced rapid reduction of growth and the second stage is ascribed to gradual accumulation of salts in the shoot of the plants at a toxic level (Machado et al.). This reduction due to salinity concentration has been observed by Bernardo et al as mentioned earlier.

Effect on Stomatal Density:

A decrease in the number of open stomata has been observed in the plants as the concentration of salinity went higher. The linear negative correlation illustrated by 3.1 graph depicts that the stomatal density decreased for all plants as the salinity concentration increased. Taro showed the highest decrease in terms of number of open stomata and Water Hyacinth showed lowest number of stomata in 30 ppt among the three plants. The value for stomatal density was 6/mm^2 in Taro whereas for Water hyacinth and Helencha there was no open stomata at 30 ppt which indicates that transpiration stopped for Water hyacinth and Helencha at 30 ppt. As level of salinity goes high the functionality of the plant's metabolism decreases hence the reduction of stomatal density is justified. Under saline stress plants inability to acquire essential amount of water leads to closure of stomata so that the plants do not lose excessive water. Moreover, the plants uptake sodium and chloride ion, it interferes with the uptake of potassium ion and disrupts stomatal regulation and causes necrosis. This phenomenon of stomatal closure due to high salinity has also been reported by other research works (Heidari et al). This stomatal closure attributes to reduced photosynthesis and reduces intercellular carbon dioxide concentration.

Effect on Transpiration rate:

As the stomatal density decreases with increasing salinity level, rate of transpiration is supposed to decline and the observed data concur with the theory. It was found that at 30 ppt rate of transpiration becomes very low in Taro .083 ml/hr whereas in case of *Enhydra Fluctuans* and of *Eichhornia crassipes* the transpiration rate was 0 ml/hr . This result is in parallel with the result found for stomatal density. As no open stomata was found in the plants at 30 ppt , it was expected that at this salinity concentration there will not be any transpiration and the result was found to be legitimate. Uptake of injurious ions by the plants leads to accumulation of these ions in plant leading to damaging chloroplasts, protein synthesis as well as other organelles. These disruptions impact the transpiration rate of the older leaves of the plants (Machado et al.) Another impact of this toxic ion accumulation is deficiency of other essential nutrients. For example it has been found that high concentration of Na^+ in water initiates calcium deficiency in plant and this has led to decreased transpiration rate in tomato plants (Machado et al). Experimentation by Jamil and Rha has also observed remarkable reduction in transpiration rate in mustard due to sodium chloride stress (Jamil et al).

Effect on Total Chlorophyll Content

Potential photosynthetic productivity and plant vigor can be indicated by chlorophyll content as the essential components required for photosynthesis are existent in chloroplast at specific molar ratios to chlorophyll. The figure 5.1 is showing that with the increasing salinity concentration, total chlorophyll content in Water Hyacinth and Helencha decreases. The highest average concentration for salinity was observed 22.22 μg/ml at 30 ppt and lowest average concentration was found 1.11 μg/ml in Water hyacinth at 30 ppt. For Taro the general trend line shows a positive relation between total chlorophyll content and salinity concentration. A plausible explanation for this result could be that in salt tolerant plants, chlorophyll content increases with accession to salinity concentration (Heidari et al.) Similarly as taro has salt tolerance capacity it exhibits this positive relation. In Water Hyacinth and Helencha the linear relationship is negative as saline stress aggravates enzymatic chlorophyll degradation. Salinity induces weakening of protein-pigment-lipid complex which increases chlorophyllase activity ; that is the initial step of breakdown of chlorophyll. Another factor that could contribute in reduction of chlorophyll content is the reduction of leaf area due to high salinity concentration that led to lower light interception. Heidari et al observed similar consequences for increased salinity concentration in *Ocimum basilicum L.*

Effect on Relative Water Content

It can be observed from graph 6.1 that the relative water content of the plants were adversely affected due to increased salinity. This reduction is RWC is the result of turgor loss due to limited water availability induced by salinity. RWC estimates the existent water content of the sample leaf in terms of the ratio of the maximum amount of water the leaf can hold at full turgidity. Usually the normal values of RWC ranges between ninety eight percent in turgid leaves and forty percent in severely desiccated leaves (Heidari et al.). At highest salinity the average RWC was found to be 37.48% which is much lesser. The significant decrease was observed in Taro relative to water hyacinth and Helencha.That indicates the other two plants adaptability in order to minimize water loss under saline stress. Another investigation in this regard has also assured rapid reduction of RWC due to high salinity in *Triticum aestivum L*(El-Bassiouny et al).

Conclusion:

Climate change has impacted and will impact globally. Moreover, with limited resource of fresh water, salinity intrusion can be a big disaster for the habitat living in an aquatic ecosystem. A large source of primary production is dependent upon the survivability of the aquatic ecosystems. Salinity intrusion will hamper the range of salinity in fresh water resources which will eventually impact the distribution of the flora in the aquatic habitat. Although in this experiment Taro had relatively less impacts among the three plants due to its salt tolerance capacity, with prolonged exposure it could not survive as the increased salinity acted at a toxic level for the hydrophytes. With limited range of salt tolerance the hydrophytes will not be able to survive and the consequences of its destruction will rebound to the humans who initiated the process of climate change in the first place. Proper measurements to decelerate global climate change have to be implemented to ensure the impregnability of not only the aquatic ecosystem but also the terrestrial ecosystem that may be is susceptible to the consequences of global climate change.

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Appendix

Change in weight (initial-final)

Salinity	Water Hyacinth (Eichhornia crassipes)	Helencha (Enhydra Fluctuans)	Taro (Colocasia esculenta)
0	3.28	-2.87	-1.31
0	7.73	-4.08	-1.31
0	3.02	1.94	-1.31
10	18.94	2.08	1.22
10	14.25	5.13	0.44
10	14.07	-1.02	-0.62
20	9.36	6.46	-0.98
20	12.27	3.03	-0.86
20	14.09	0.94	-1.45
30	16.56	5.98	1.47
30	15.19	7.76	0.88
30	13.6	6.06	0.74

Change in height (initial-final)

Change in height (initial-final)			
Salinity	Water Hyacinth (Eichhornia crassipes)	Helencha (Enhydra Fluctuans)	Taro (Colocasia esculenta)
0	-3	-3	3
0	0	-7	3
0	-1	-6	3

10	3.5	5	-3
10	-2	18	-1
10	2	-2	4
20	-1	2	-5
20	4	-18	-7
20	3	3	2
30	3.5	-10	9
30	3	-14	7
30	8	1	5

Transpiration rate

Time (hr)	Salinity Concentration	Water Hyacinth (Eichhornia crassipes)	Helencha (Enhydra Fluctuans)	*Taro (Colocasia esculenta)*
24 hr	0	0.1666666667	0.4166666667	0.04166666667
48 hr	0	0.125	0.1666666667	0.04166666667
72 hr	0	0.2083333333	0.25	0.08333333333
24 hr	10	0.4166666667	0.1666666667	0.08333333333
48 hr	10	0	0.04166666667	0.4166666667
72 hr	10	0.1666666667	0.04166666667	0.08333333333
24 hr	20	0	0.1666666667	0.08333333333
48 hr	20	0	0.08333333333	0.3333333333
72 hr	20	0	0	0.08333333333
24 hr	30	0	0.08333333333	0.08333333333
48 hr	30	0	0	0
72 hr	30	0	0	0.08333333333

Total Chlorophyll Content

Salinity concentration	Water Hyacinth (Eichhornia crassipes)	Helencha (Enhydra Fluctuans)	Taro (Colocasia esculenta)
	1.24404	3.81622	8.53626
	1.37712	0.88996	8.53626
0	1.1674	1.80012	8.53626
	2.23084	6.19888	13.13578
	67.7657	6.51076	12.013756
10	1.57466	7.96482	44.79908
	1.53426	3.54946	40.22662
	0.91432	1.89786	14.27466
20	0.84986	4.70052	12.9424
	0.95026	3.31838	18.32728
	1.09552	1.19712	13.57928
30	1.29662	2.15866	21.83394

Stomatal density

Salinity	Water Hyacinth (Eichhornia crassipes)	Helencha (Enhydra Fluctuans)	Taro (Colocasia esculenta)
0	6.843864396	1.233487188	22.91898774
10	5.729746936	0.4376890021	10.34537641
20	1.591596371	0.278529365	7.639662582

30	0	0.2387394557	5.888906573

Relative Water Content

Relative water Content= [(W-DW) / (TW-DW)] x 100			
Salinity Concentration	Water Hyacinth (Eichhornia crassipes)	Helencha (Enhydra Fluctuans)	*Taro (Colocasia esculenta)*
0	97.03389831	100	97.95918367
0	40.96385542	85.71428571	97.95918367
0	99.3006993	86.66666667	97.95918367
10	46.15384615	75	40
10	112.0689655	87.5	38.46153846
10	82.35294118	100	100
20	57.41935484	100	75
20	80	100	14.28571429
20	2.941176471	92.85714286	66.66666667
30	61.2244898	66.66666667	20
30	64	100	45.45454545
30	6.212121212	0	50