What effect do different salt concentrations have on *Rotala Indica* plant growth (this will be determined by determining the plant's mass after a week)?

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2760 words

Abstract

It is interesting to examine how higher salt concentrations affect plant life. In this study, an experiment will be carried out to look into this impact. Sodium chloride (NaCl) plays a crucial function since it includes the Na+ ion, the primary electrolyte for maintaining the ionic equilibrium in tissues and fluids. However, it should be noted that most plants generally react poorly to moderate and high levels of salt. Because inorganic ions like Na+ and Cl- are present, higher salinity levels tend to inhibit plant growth by lowering water potential. Osmotic stress consequently results from significant changes in water potentials, which interfere with regular cellular functions. The goal of the experiment is to simulate the effects of changing the environment's salinity on plant life. Changing the salt concentration throughout the experiment will be accomplished. Rotala Indica was chosen as a suitable subject for this investigation because it is a glycophyte frequently seen in freshwater aquariums. To replicate the salinity levels found in seawater, different salt concentrations ranging from 0% to 1.6% will be used.

Keywords: Sodium chloride, salt concentration, Rotala indica

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Research Question

What effect does salt concentration have on the Rotala Indica plant's growth as indicated by its mass one week later?

Introduction

Nano aquariums frequently contain *Rotala Indica*, an aquatic plant. It has phenotypic plasticity, which enables it to adjust to different environments. It can grow from about 5 cm to a maximum of 30 cm and has soft stems. *Rotala Indica*, a native of Southeast Asia, flourishes in wetlands and rice paddies (Ashouri et al., p 103528). The increasing salinity of freshwater brought on by human activities like mining, oil extraction, and groundwater discharge is the driving force behind this research question.

This paper suggests an experiment that simulates changes in salt concentration in order to comprehend the effects of salt concentration on plant life. Rotala Indica was chosen because it belongs to the glycophyte class and is frequently used in freshwater aquariums. For the experiment, different salt concentrations ranging from 0% to 1.6% are used to simulate the salinity of seawater. These factors also relate to the 17 sustainability goals of the UN, particularly goal number 13 on climate action. The outlined changes provide proof of how global warming affects plant life. The purpose of this investigation is to clarify the effects of global warming.

Not only is comprehending the impact of salt concentration on Rotala Indica vital to ecological researchers, but it plays a crucial role in practical applications like managing saltwater intrusion in coastal regions or refining irrigation methods used in agriculture. To gain greater clarity regarding salt concentrations' relationship with Rotala Indica's response, this study focuses on measuring mass as an indicator of growth progression. This examination yields rewarding understandings related to this plant species' adaptability and resilience within varying saline surroundings that are pertinent across multiple ecosystems. The comprehensive experimentation methodology applied, coupled with thorough data analysis, facilitates advancing scientific understanding pertaining to salinity stresses faced by crops, facilitating future research studies towards effective mitigation strategies addressable through policy or precision agriculture intervention programs. Moreover, studying the intricate interplay between plants and their environment has intrinsic value, challenging us by exploring puzzles furnished by both plant adaptability tendencies amid shifting environmental stressors.

Investigation

Hypothesis

H1: Rotala indica will experience a reduction in growth overall if the concentration of NaCl is raised after one week.

H0: Increasing the concentration of NaCl has no impact on *Rotala Indica*'s overall growth.

Background Information

The Na^+ ion, which is present in sodium chloride (NaCl), is essential for preserving the ionic balance in tissues and fluids (Amin et al., p581). However, moderate and high salt levels negatively affect the majority of plants. Due to high levels of inorganic ions like Na^+ and Cl^-, which lower water potential and cause osmotic stress, increased salinity inhibits plant growth. Osmotic stress happens when substantial changes in water potential impair regular cellular functions.

On the other hand, because they can effectively balance and restrict the intake of Na^+ ions, halophytes (seawater plants) can withstand moderate and high salt levels. They accomplish this through efficient cellular partitioning and translocation to the plant's shoots. Rotala

Indica, a glycophyte, cannot tolerate salt, though. It cannot successfully restrict the intake of Na^+ and Cl^- ions when exposed to NaCl, which has a negative effect. This lends support to the idea that Rotala Indica's ability to withstand higher salt concentrations will prevent it from growing as NaCl concentrations rise.

Variables

Independent Variables

Varied salt concentration solutions: 1.6% salt solution, 1.2% salt solution, 0.8% salt solution, 0.4% salt solution, and 0% salt solution

Dependent Variable

Biomass of Rotala Indica after one week (±0.001g)

Controlled Variables

Variable	Controlled	Reason
Temperature	Maintained at 27°C using a thermometer	27°C is the optimal temperature for Rotala Indica to ensure consistent growth
The volume of Distilled Water	Maintained at 800cm3 using a measuring cylinder	Ensures a consistent water volume for each setup
Number of Plants	Maintained at 5 plants in each 1000ml beaker	Prevents overcrowding, allowing adequate space for each plant to grow
Mass of Soil	Maintained at 200g of shrimp soil in each beaker	Provides a consistent medium for anchoring the plants and promoting their growth
Stirring Technique	30 stirs in the clockwise direction for all salt solutions	Ensures uniform dissolution of NaCl in the distilled water
Light Intensity	Same number of light bulbs (2) with 120 volts	Maintains consistent light conditions across all setups
Humidity	Maintained at 37% using a hygrometer	Ensures a consistent humidity level for all setups

Table 1: Controlled variables in the investigation

List of Apparatus

Apparatus	Description
Hygrometer	×1
Retort stands	×2
Light bulbs	×5, (120v)
Shrimp Soil	1000g
Rotala Indica cultures	×2
Measuring cylinder	×3, 100cm3 ($\pm$ $1cm3$)
Spatula	×1
Aquarium tweezer	×1
Glass rod	×2
White tile	×3
Powdered NaCl	200g
Electronic Balance	×1 ($\pm 0.001cm3$)
Weighing boat	×2
1000cm3 Beaker	×5
Distilled water	4000cm3

Table 2: The apparatus list and their description

Material

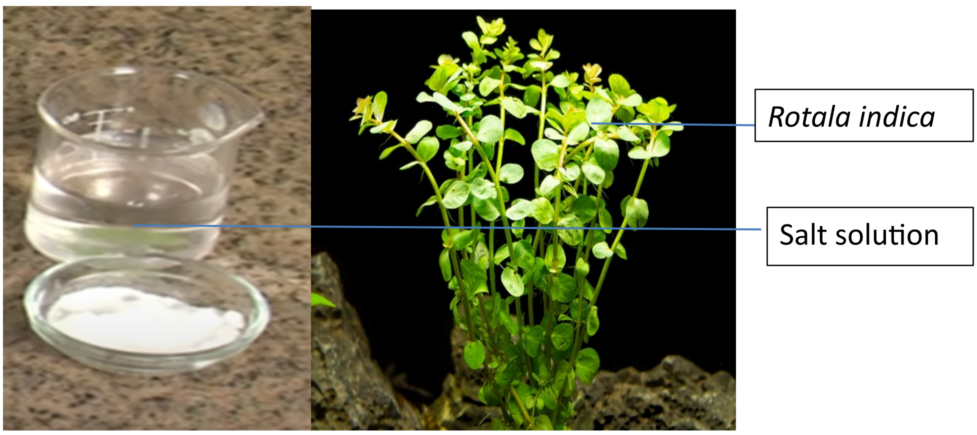

Figure 1; Material

Procedure

1. 160g of shrimp soil should be weighed in a weighing boat using an electronic mass balance.
2. A clean measuring cylinder should be used to add 100cm3 of distilled water to a 1000cm3 beaker.
3. Use a spatula to scoop 16g of NaCl into a weighing boat, then weigh it with a mass balance.
4. The distilled water in the 1000cm3 beaker should be mixed with 16g of NaCl.
5. Using a glass rod, stir the mixture until all of the sodium chloride has disintegrated.
6. The NaCl solution in the beaker should have 160g of shrimp soil added, and the dirt should be let to sink to the bottom.
7. Place the cultured Rotala Indica in a water basin and add 3.5 liters of distilled water to it.
8. After separating the plants and placing each one separately on a white tile, rinse the gel that is attached to the cultured Rotala Indica in the water basin.
9. Use a mass balance to weigh each plant individually, then record the results.
10. Five plants should be added to the NaCl solution and soil mixture using an aquarium tweezer. Make sure the plants are anchored by burying their roots beneath the soil surface to prevent floating.
11. Mark the location of each plant in the solution and identify the mixture as the 1.6% salt solution setup.
12. Put the 1.6% salt solution setup in a well-lit, enclosed space.
13. Use an electronic balance to determine the Rotala Indica plants' final mass after one week.

14. With different NaCl concentrations of 1.2%, 0.8%, and 0.4%, and a solution without salt, repeat steps (1) to (14). Follow the same procedure for 12g, 8g, 4g, and 0g of NaCl, respectively.

Risk Assessment

Safety Issues

When handling powdered NaCl, eye protection is crucial to avoid coming into contact with it.

Ethical Issues

There were no unethical issues with the methodology used for this experiment.

Environmental Issues

Environmental concerns were not present during this experiment.

Results:

Qualitative Observations

The Rotala Indica displayed a brighter green color in the no salt solution and 0.4% salt solution setups as opposed to the darker and paler green color seen in the 0.8%, 1.2%, and 1.6% salt solutions. Additionally, the 0.4% salt solution's Rotala Indica had a paler green hue than the no-salt solutions. Compared to the plants in the other setups, the Rotala Indica in the control setup (without salt solution) seemed more turgid. Of all the setups, the 1.6% salt solution produced the most flimsy plants. The Rotala Indica had the most leaves in the control setup, while the salt concentrations of 0.8%, 1.2%, and 1.6% had the fewest.

Quantitative Observation

0%	**Mass (+0.001g)**			
Plant No.	**Initial mass**	**Final mass**	**Difference in mass**	**Change in mass (%)**
1	0.380	0.499	0.119	31.04
2	0.401	0.523	0.122	30.16
3	0.380	0.496	0.116	30.17
4	0.410	0.542	0.132	31.94
5	0.351	0.457	0.106	30.28

Table 3: percentage change in mass for 0% salt solution

0.4%	**Mass (+0.001g)**			
Plant No.	**Initial mass**	**Final mass**	**Difference in mass**	**Change in mass (%)**
1	0.434	0.482	0.048	10.79
2	0.400	0.447	0.047	11.46
3	0.421	0.465	0.044	10.20
4	0.463	0.513	0.050	10.55
5	0.442	0.493	0.051	11.33

Table 4: percentage change in mass for 0.4% salt solution

0.8%	**Mass (+0.001g)**			
Plant No.	**Initial mass**	**Final mass**	**Difference in mass**	**Change in mass (%)**
1	0.426	0.342	-0.086	-19.90
2	0.419	0.324	-0.095	-22.90
3	0.428	0.337	-0.091	-21.49
4	0.442	0.348	-0.096	-21.48
5	0.402	0.309	-0.093	-22.93

Table 5: percentage change in mass for 0.8% salt solution

1.2%	**Mass (+0.001g)**			
Plant No.	**Initial mass**	**Final mass**	**Difference in mass**	**Change in mass (%)**
1	0.397	0.223	-0.174	-43.68
2	0.413	0.236	-0.177	-42.36
3	0.454	0.264	-0.190	-41.71
4	0.454	0.271	-0.183	-40.17
5	0.405	0.226	-0.179	-43.94

Table 6: percentage change in mass for 1.2% salt solution

1.6%	**Mass (+0.001g)**			
Plant No.	**Initial mass**	**Final mass**	**Difference in mass**	**Change in mass (%)**
1	0.427	0.208	-0.219	-51.41
2	0.453	0.216	-0.237	-51.98
3	0.401	0.190	-0.211	-52.36
4	0.417	0.197	-0.220	-52.65
5	0.462	0.229	-0.233	-50.32

Table 7: percentage change in mass for 1.6% salt solution

Data Analysis

Salt solution	**Average Difference (+0.001g)**	**Average change in mass (%)**
0%	0.117	30.72
0.40%	0.046	10.87
0.80%	-0.091	-21.74
1.20%	-0.178	-42.37
1.60%	-0.222	-51.74

Table 8: Average change in mass and percentage change

Sample Evaluation

Calculation for;

$$difference\ in\ mass\ (g)\ =\ Final\ mass\ (g) - Initial\ Mass\ (g)$$

For the 1.6% salt solution

$$(plant\ 1):\ 0.208\ -\ 0.427\ =\ -0.219$$

Calculation for;

$$average\ difference\ in\ mass\ =\ (Total\ difference\ in\ mass\ for\ all\ 5\ plants)\ /\ 5$$

$$For\ the\ 1.6\%\ salt\ solution:\ (-0.219\ -\ 0.237\ -\ 0.211\ -\ 0.220\ -\ 0.233)\ /\ 5\ =\ 0.222g$$

Calculation for;

$$percentage\ change\ in\ mass\ =\ (Difference\ in\ mass)\ /\ (Initial\ mass)\ \times\ 100\%$$

$$For\ the\ 1.6\%\ salt\ solution\ (plant\ 1):\ (-0.219)\ /\ 0.427\ \times\ 100\ =\ -51.40\%$$

$$Average\ percentage\ change\ in\ mass\ =\ (Total\ percentage\ change\ in\ mass\ for\ all\ 5\ plants)\ /\ 5$$

$$For\ the\ 1.6\%\ salt\ solution:\ (-51.40\ -\ 51.98\ -\ 52.37\ -\ 52.64\ -\ 50.33)\ /\ 5\ =\ -51.74\%$$

$$Max\ \%\ error\ =\ (Uncertainty\ of\ electronic\ balance)\ /\ (lowest\ dependent\ variable\ value)\ \times\ 100\%$$

$$=\ \frac{0.001}{0.191} \times\ 100\%$$

$$=\ 0.524\%$$

Regression Analysis

The regression analysis provides an analysis of the correlation between the salt concentration and the percentage change in the mass of *Rotala indica.* The analysis is also utilized in the evaluation of the Anova to test the null and alternative hypotheses described in the hypothesis section above. The analysis is carried out by use of the data analysis tool back in Excel;

Regression Statistics	
Multiple R	0.9703
R Square	0.941482
Adjusted R Square	0.912222
Standard Error	8.217369
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2172.779	2172.779	32.17732	0.0297
Residual	2	135.0503	67.52516		
Total	3	2307.829			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	25.87	10.06418	2.570502	0.123847	-17.4327	69.17268
0	-5211.5	918.7298	-5.67251	0.0297	-9164.48	-1258.52

Table 9: The regression analysis table summary

The correlation value of 0.9703 in the table above indicates a strong correlation between the salt concentration and the percentage change in Rotala indica mass. We reject the null hypothesis and accept the alternative one because the significant F value is less than 0.05, which leads us to draw the conclusion that Rotala indica grows less generally if the concentration of NaCl is increased after one week.

Graph

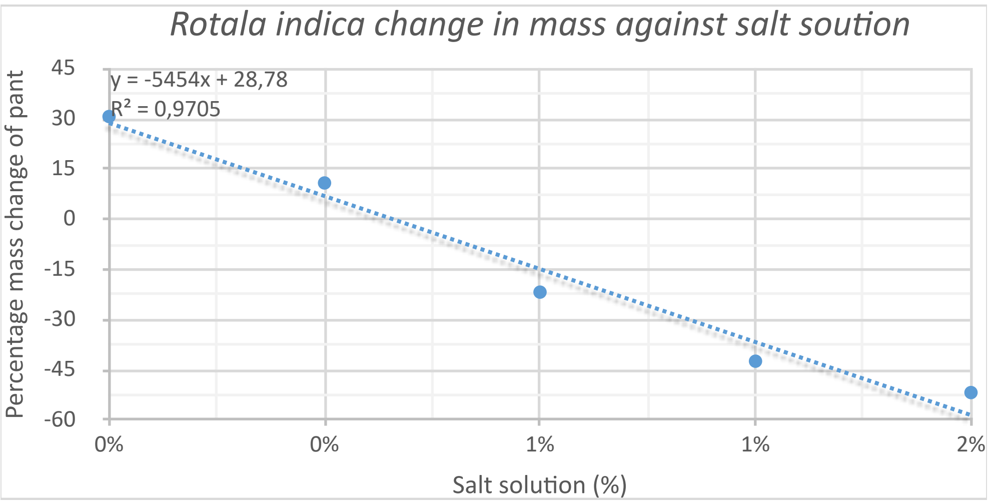

Figure 2: Graph of mass change of *Rotala indica* against the concentration of the salt solution

The graph displays a negatively sloped line demonstrating an inverse association between the concentration of the salt solution and the percentage change in *Rotala indica* mass. The correlation coefficient is 0.9705, a high correlation coefficient. Since there is a negative connection and the graph's slope is negative, we can see that the percentage change in the ass decreases as the salt content rises.

Conclusion

The findings show that the average percentage change in the mass of Rotala Indica decreases as the salt concentration rises. This suggests that salt concentrations that are both high and moderate have a negative effect on the mass of the plant. The alternative hypothesis (H1) that higher salt concentrations cause decreased growth is supported by the rejection of the null hypothesis (H0). Both the raw data and the graph, which show a consistent downward trend in the average percentage change in mass, support this conclusion.

The higher Na+ and Cl- ion concentrations in the salt solutions are to blame for the mass loss. Due to the decrease in water potential in the solution, as a result, the cells of Rotala Indica have a lower water potential. Osmotic stress consequently develops, reducing photosynthesis and causing stomata closure, which ultimately results in a decrease in biomass (Chaudhry and Sidhu, 016). This finding was particularly clear in the salt solutions of 0.8%, 1.2%, and 1.6%, where there was a negative difference in biomass between the final and initial measurements. Less photosynthesis occurs in salt solutions with higher NaCl concentrations (Kwon et al., p832). Water moves from the Rotala Indica cells, which have a higher water potential, to the nearby salt solution, which has a lower water potential, as a result of osmotic stress. While ensuring a homogeneous mixture, this osmotic movement also lowers the water potential in Rotala indica cells (Gupta et al., p162757). A decrease in water potential results in a reduction in photosynthesis because there is less water available for the process, which needs water, carbon dioxide, and light as reactants.

Additionally, osmosis causes Rotala indica cells to undergo plasmolysis, in which the cell membrane separates from the cell wall and lowers turgor pressure as a result. Higher salt concentrations were observed to cause the plant to become flaccid. The negative percentage change in mass observed in the 0.8%, 1.2%, and 1.6% salt solutions suggests that the Rotala Indica plants may eventually perish.

Evaluation

Strengths

- The Rotala Indica was able to carry out its metabolic functions to their fullest potential thanks to constant temperature monitoring at a specific time that guaranteed a constant temperature of 27°C. Thus, the concentration of salt was the only factor influencing plant growth.
- Consistent humidity checks kept the relative humidity in all setups at 37%, preventing condensation and keeping the salinity of the salt solution where it was supposed to be.
- The use of distilled water ensured that the concentration of salt was the only thing that mattered by removing any minerals that might have had an impact on plant growth.
- Different initial masses were taken into account, exponential growth was accommodated, and accurate mass differences were provided by computing the percentage change in mass.
- The precision and certainty of the experimental results were improved by a low maximum percentage error, which reduced systematic errors.

Weaknesses

- No precise quantitative information, such as the number of leaves or height, was gathered. The rate of photosynthetic growth and general development of Rotala Indica may have been impacted by this lack of information. A more thorough analysis that would confirm or deny the hypothesis would be produced by taking these factors into account.
- *Rotala indica's* CO_2 intake was not monitored, which might have had an effect on photosynthesis and plant development. A controlled variable and a more targeted analysis would have been made possible by monitoring carbon dioxide levels in the setups.

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