Ocean Acidification: A Rising Global Problem

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Key Terms

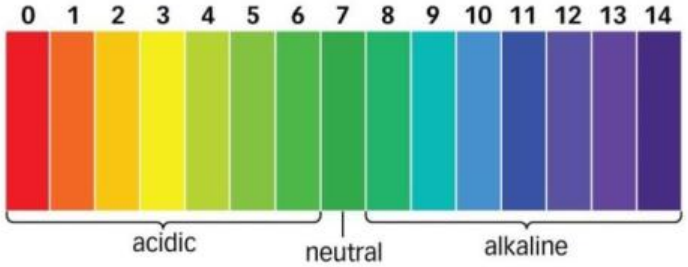
- **pH:** A measure of hydrogen ion concentration in a substance, which indicates acidity or alkalinity.
- **Acid:** A chemical substance that neutralizes with alkalis.
- **Acidity:** The level of acid present in a solution. If the pH level is less than 7, it is considered to be acidic.
- **Alkali:** A chemical compound that neutralizes with acids.
- **Alkalinity:** The level of alkali present in a solution. If the pH level is greater than 7, it is considered to be alkaline.
- **Acidification:** The act of increasing in acidity.

Key Terms Cont'd.

- **Calcium Carbonate ($CaCO_3$):** A white solid that forms mollusk shells and stony corals. It is insoluble in water.
- **Carbon Dioxide (CO_2):** A greenhouse gas formed by burning carbon and organic compounds and by respiration.
- **Global Warming:** An increase in the overall temperature of the Earth's atmosphere due to the greenhouse effect.
- **Erosion:** Gradually wearing away of soil, rock, or land through wind, water, or other natural phenomenons.
- **Hydrogen (H):** A highly flammable gas, which is colorless and odorless, that combines chemically with oxygen to form water.

Variables

- **Independent Variable:** The pH of water
  - The pH levels of 3, 5, 7, 9, and 11 will be used
- **Dependent Variable:** The difference in mass of the original shell to the shell after being dissolved
  - This will allow the researcher to determine the effect of pH on calcium carbonate shells of aquatic animals



Variables Cont'd.

- **Controlled Variables:**
  - Temperature of testing room (22℃)
  - Temperature of water (22℃)
  - Mass of calcium carbonate chips (5 g)
  - Type of calcium carbonate chip (weight, size, color, etc.)
  - Type of jar
  - Amount of solution (150 mL)
  - Amount of time chips dissolve in solutions (72 hours)
- **Control Group:** pH level of 7 because it is neutral

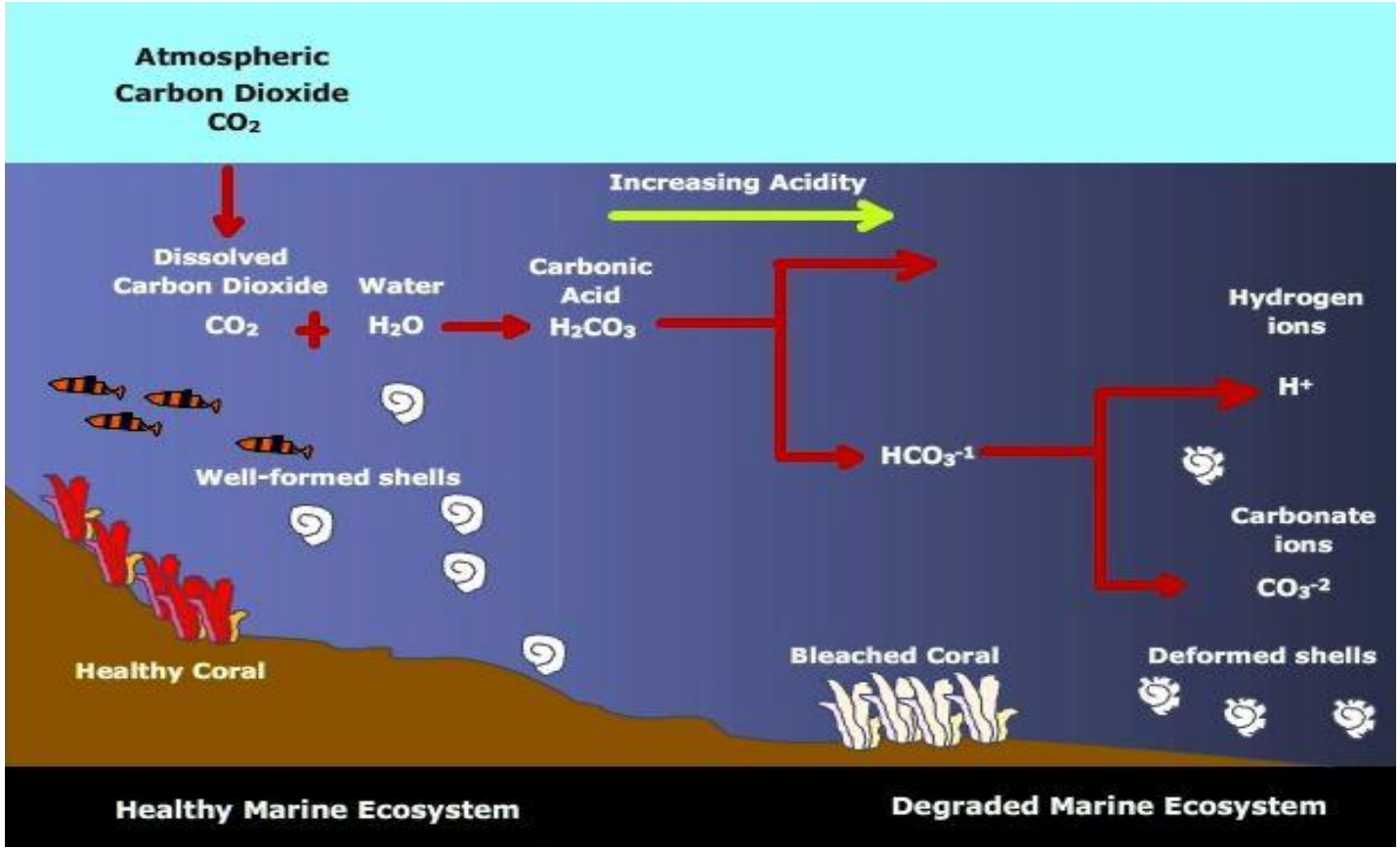
Scientific Processes

- pH measures the acidity/alkalinity of a liquid solution
- It is measured between 0 to 14; 7 is considered to be neutral
- If a pH level is less than 7, it is acidic
- If a pH level is greater than 7, it is basic or alkaline
- pH stands for “potential of Hydrogen”
- When adding a substance to water, the water molecule splits up into two separate ions, hydroxide (OH^-) and hydrogen (H^+)
- As the the hydrogen ions increases, the pH level decreases and becomes more acidic

Scientific Processes Cont'd.

- Ocean Acidification is a reduction in the pH of the ocean over a long period of time
- Occurs due to the increase of CO_2 in the Earth's atmosphere
- When CO_2 is absorbed into the seawater, there is an increase in the concentration of hydrogen ions, which causes the seawater to become acidic, as well as the carbonate ions to decrease
- Carbonate ions are essential for calcium carbonate structures
- Due to the decrease in the carbonate ions, building and maintaining calcium carbonate structures is very difficult for calcifying organisms

Scientific Processes Cont'd.



Significance of Project

- This experiment was chosen because the researcher is very interested in nature and wants to conserve it.
- The researcher also knew about the global problem of ocean acidification, and wanted to help.
- People who are studying oceans and marine life, or about ocean acidification, in particular, will benefit from knowing about this.
- This experiment will benefit people who want to know more about the effects of ocean acidification on animals, and it will explain the impact of pH on the structure of calcium carbonate shells

Research Question

What is the effect of changing the pH of water (3, 5, 7, 9, and 11) on calcium carbonate shells of organisms that live in aquatic bodies?

Hypothesis

If a calcium carbonate shell was placed in different pHs of water (3, 5, 7, 9, and 11), then the water with a pH level of 3 would dissolve the most amount of calcium carbonate shell.

Hypothesis Cont'd.

According to https://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F, as water becomes more acidic, there are fewer carbonate ions. Carbonate ions are important building blocks for structures like calcium carbonate shells. Due to having less carbonate ions, calcium carbonate shells will dissolve the most amount when at a low pH level, which is more acidic. As carbonate ions decrease, the pH level also decreases. Therefore, the shells will dissolve the most at a pH of 3 rather than at a higher level of pH.

Hypothesis Cont'd.

According to https://www.whoi.edu/oceanus/feature/ocean-acidification-a-risky-shell-game/, CO_2 also plays a really big role in ocean acidification. Excess carbon dioxide is dissolved into the seawater of the ocean. The dissolved CO_2 in the ocean is then converted into corrosive carbonic acid. This process is also known as ocean acidification. Consequently, an increase of CO_2 in the oceans will cause the pH level to decrease and the environment to become more acidic.

Materials

- 25 mason jars
- 25 calcium carbonate chips
- 750 mL of vinegar
- 750 mL of orange juice
- 1500 mL of distilled water
- 17.5 grams of baking soda
- 750 mL of household ammonia
- pH strips
- pH scale
- 1 stopwatch

Materials Cont'd.

- 1 thermometer
- 1 digital scale
- 1 roll of paper towels
- 1 roll of masking tape
- 1 permanent marker
- 1 250 mL graduated cylinder
- Measuring spoons
- Cardboard
- Latex and powder-free disposable medical gloves

Procedure

1. Gather all materials.

2. Wear disposable gloves on both hands for safety precautions.

3. Using a permanent marker and masking tape, label a mason jar with vinegar.

4. Take the mason jar and fill it with 150 mL of vinegar.

5. Take one side of a pH strip and dip it into the vinegar for 2 seconds to make sure it has a pH level of 3.

6. Take the strip out of the vinegar, and wait for 10 more seconds.

7. Using a pH scale, compare the color of the pH strip with the colors on the scale to find the pH level of the solution.

Procedure Cont'd.

8. Measure and record the pH level for the solution.

9. Repeat steps 1 through 8, but with the following solutions: 150 mL orange juice, 150 mL distilled water, 3.5 grams baking soda combined with 150 mL distilled water, and 150 mL household ammonia to make sure they have a pH level of 5, 7, 9, and 11, respectively.

10. Take 5 calcium carbonate chips, rinse them with water, and let them dry.

11. Using a digital scale, measure and record the mass of each chip separately, making sure each has a mass of 5 grams.

12. Using a thermometer, make sure the temperatures of the solutions are the same at 22℃.

Procedure Cont'd.

13. Put a calcium carbonate chip in each of the 5 solutions, cover the jars with cardboard, and then leave them for 72 hours.

14. After 72 hours, remove the chips, place on paper towels, and measure and record their masses after being dissolved, with the digital scale.

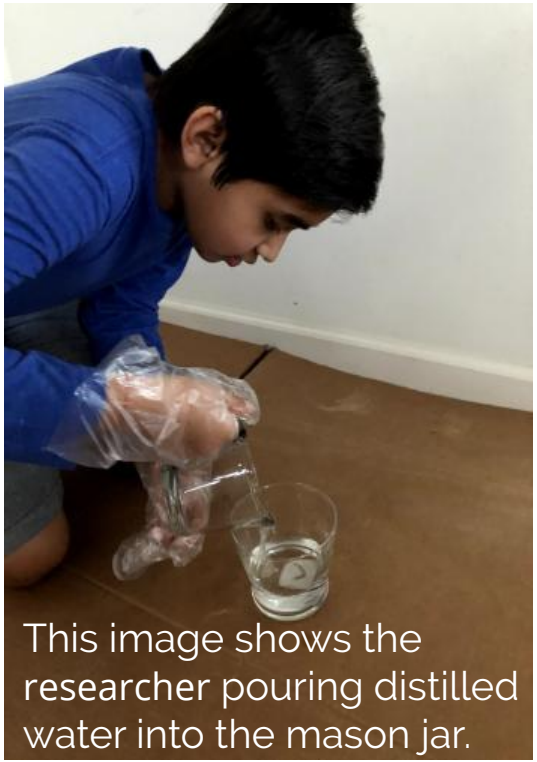
15. Use the formula below to calculate the percentage difference in the mass from the original chip to the chip after being dissolved in the solution.

$$\frac{\text{Mass of original - Mass of final}}{\text{Mass of original}} \text{ X 100 = Percentage difference}$$

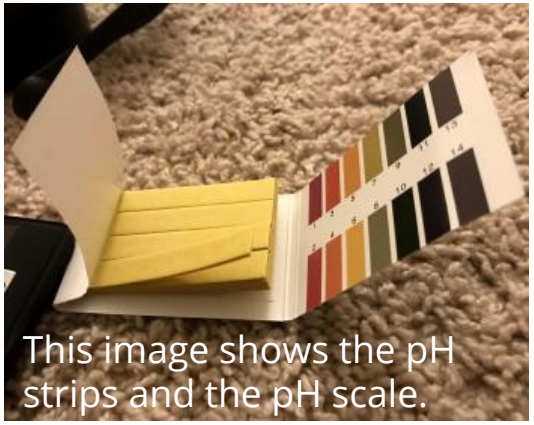
16. Repeat steps 1 through 15 4 more times for a total of 5 trials.

Procedure Cont'd.

This image shows the solutions in the mason jars.



This image shows the researcher pouring distilled water into the mason jar.



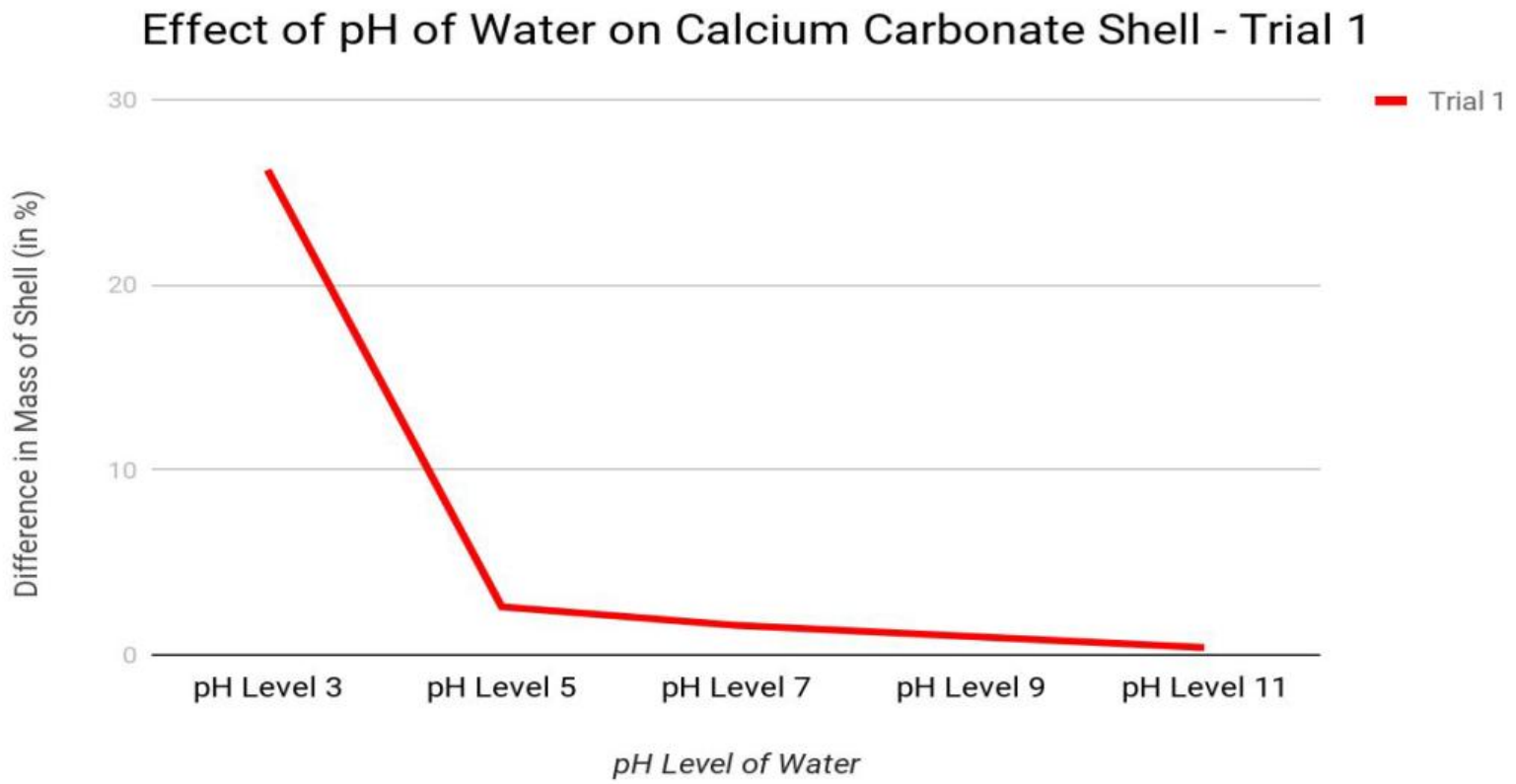
This image shows the pH strips and the pH scale.

This image shows the mass of the calcium carbonate chips.

Effect of Different pH's of Water on Calcium Carbonate Shells

pH Level	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average
pH Level 3	26.20%	29.80%	27.00%	29.20%	32.60%	28.96%
pH Level 5	2.60%	2.40%	3.60%	2.80%	3.20%	2.92%
pH Level 7	1.60%	1.80%	2.40%	2.00%	2.20%	2.00%
pH Level 9	1.00%	0.60%	1.60%	1.20%	1.40%	1.16%
pH Level 11	0.40%	0.20%	0.60%	0.40%	0.60%	0.44%

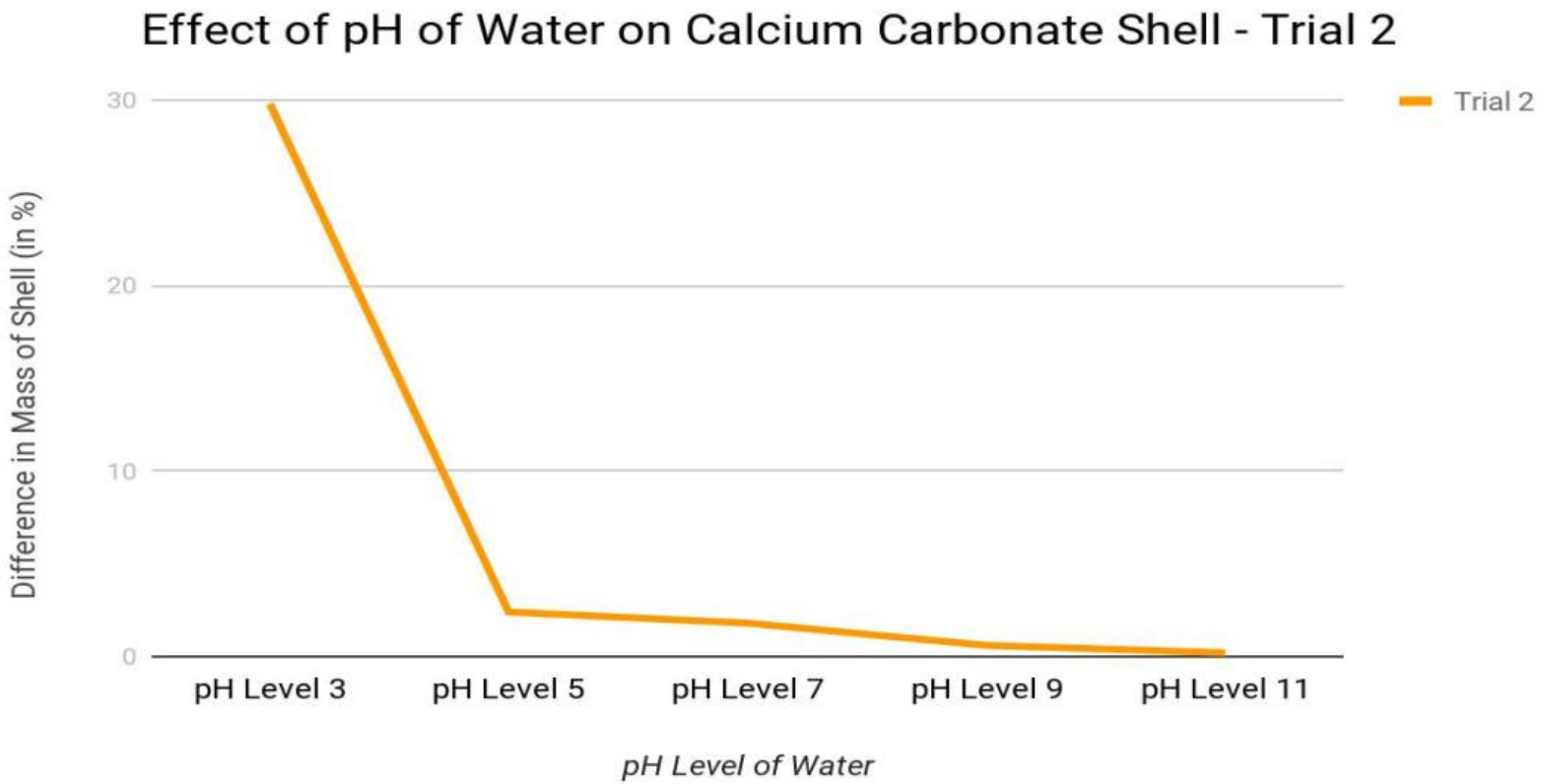
Data


Effect of pH of Water on Calcium Carbonate Shell - Trial 1
Trial 1
30
20
10
0
Difference in Mass of Shell (in %)
pH Level 3
pH Level 5
pH Level 7
pH Level 9
pH Level 11
pH Level of Water

Data Analysis

In **trial 1**, the calcium carbonate chip in the solution with a pH level of 3 dissolved 26.20% of its original shell. With the calcium carbonate chips put in the pH levels of 5, 7, 9, and 11 only dissolving at 2.60%, 1.60%, 1.00%, and 0.40%, respectively. This supports the hypothesis with a decreasing trend.

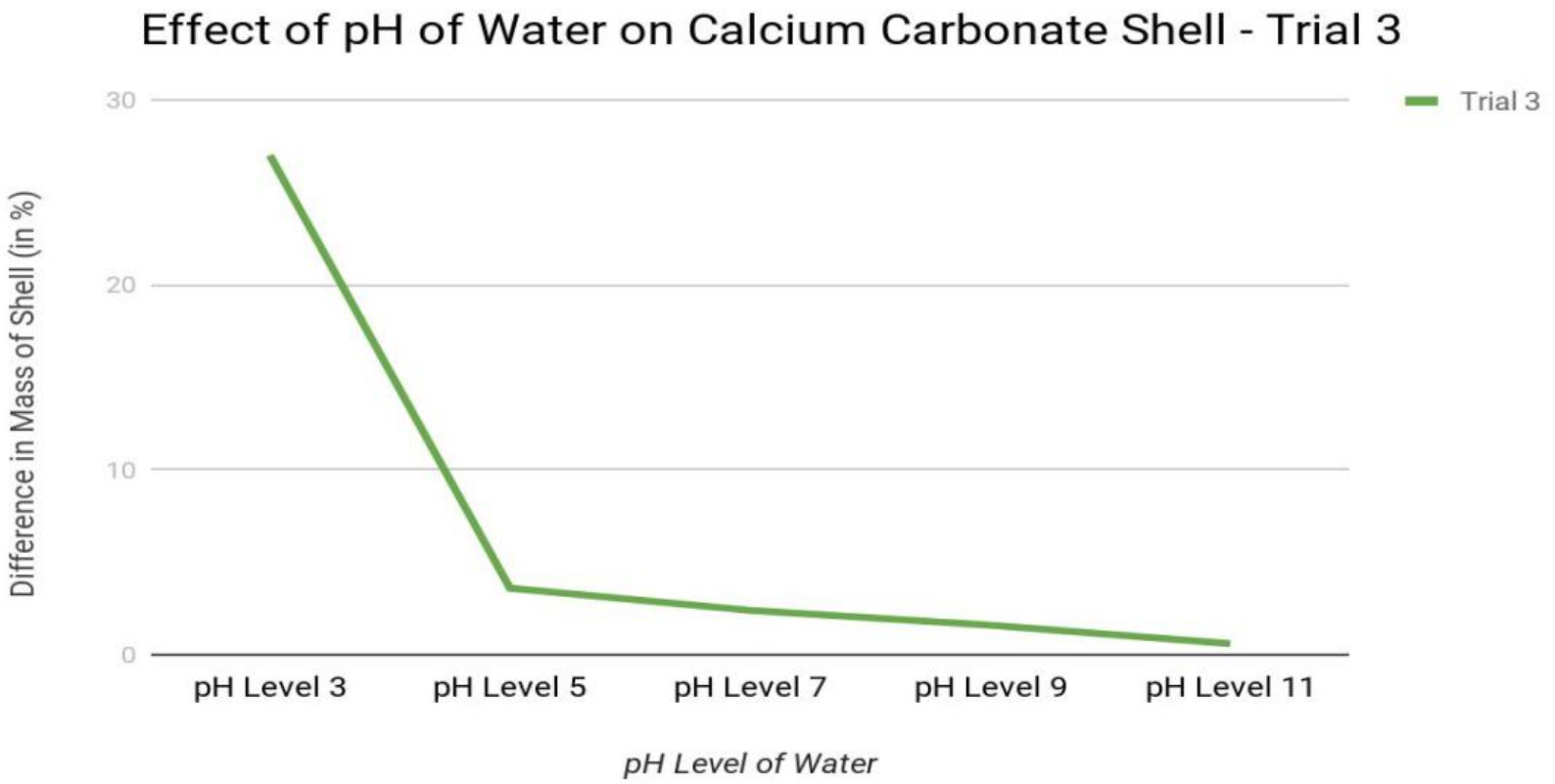
Data Cont'd.


Effect of pH of Water on Calcium Carbonate Shell - Trial 2
Trial 2
30
20
10
0
Difference in Mass of Shell (in %)
pH Level 3
pH Level 5
pH Level 7
pH Level 9
pH Level 11
pH Level of Water

Data Analysis Cont'd.

In **trial 2**, the calcium carbonate chip in the solution with a pH level of 3 dissolved the most with it dissolving 29.80% of its original shell. With the calcium carbonate chips put in the pH levels of 5, 7, 9, and 11 only dissolving at 2.40%, 1.80%, 0.60%, and 0.20%, respectively. This supports the hypothesis with a decreasing trend.

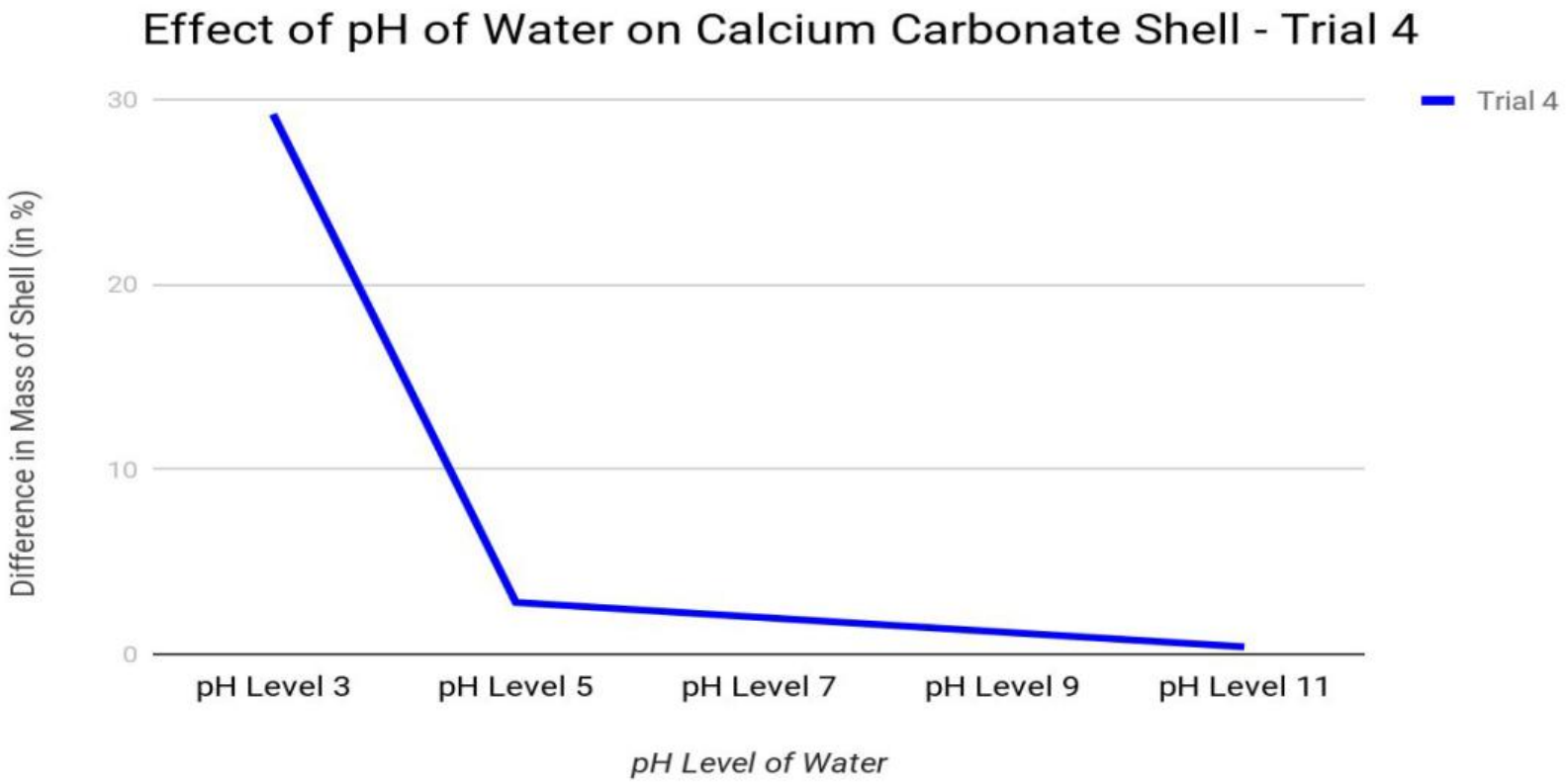
Data Cont'd.


Effect of pH of Water on Calcium Carbonate Shell - Trial 3
Trial 3
30
20
10
0
Difference in Mass of Shell (in %)
pH Level 3
pH Level 5
pH Level 7
pH Level 9
pH Level 11
pH Level of Water

Data Analysis Cont'd.

In **trial 3**, the calcium carbonate chip in the solution with a pH level of 3 dissolved 27.00% of its original shell. With the calcium carbonate chips put in the pH levels of 5, 7, 9, and 11 only dissolving at 3.60%, 2.40%, 1.60%, and 0.60%, respectively. This supports the hypothesis with a decreasing trend.

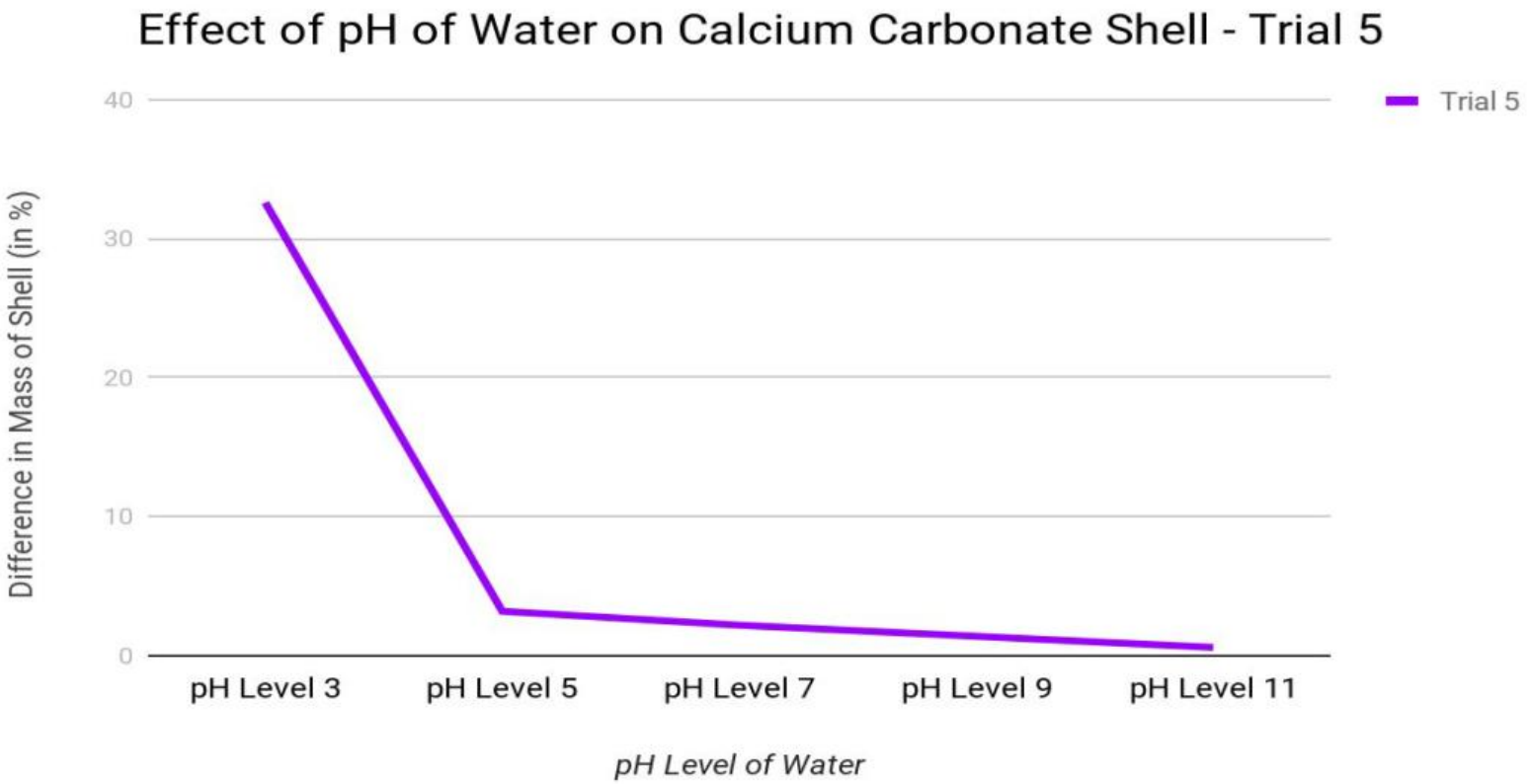
Data Cont'd.


Effect of pH of Water on Calcium Carbonate Shell - Trial 4
Trial 4
30
20
10
0
Difference in Mass of Shell (in %)
pH Level 3
pH Level 5
pH Level 7
pH Level 9
pH Level 11
pH Level of Water

Data Analysis Cont'd.

In **trial 4**, the calcium carbonate chip in the solution with a pH level of 3 dissolved the most with it dissolving 29.20% of its original shell. With the calcium carbonate chips put in the pH levels of 5, 7, 9, and 11 only dissolving at 2.80%, 2.00%, 1.20%, and 0.40%, respectively. This supports the hypothesis with a decreasing trend in the data.

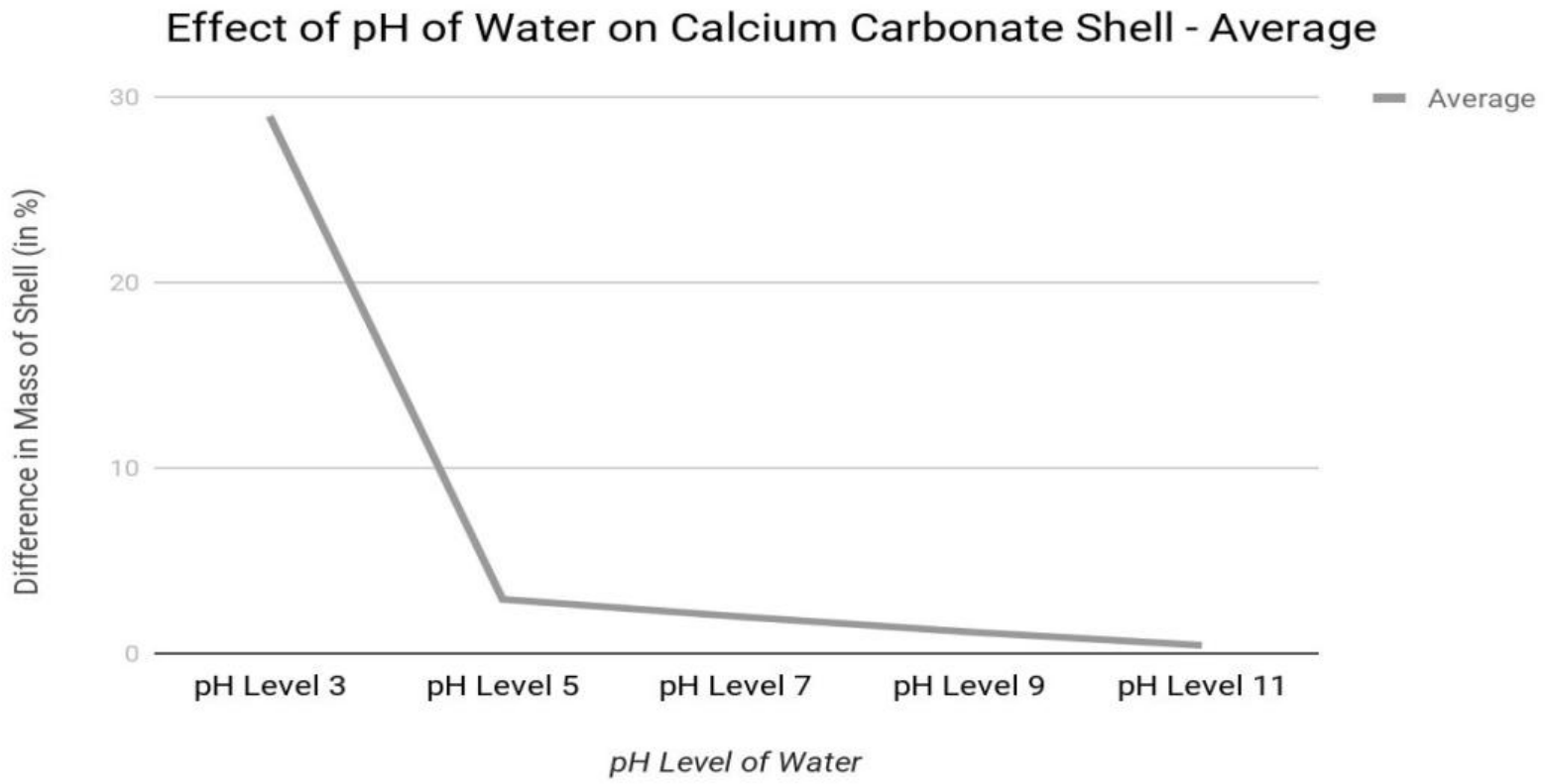
Data Cont'd.


Effect of pH of Water on Calcium Carbonate Shell - Trial 5
Trial 5
40
30
20
10
0
Difference in Mass of Shell (in %)
pH Level 3
pH Level 5
pH Level 7
pH Level 9
pH Level 11
pH Level of Water

Data Analysis Cont'd.

In **trial 5**, the calcium carbonate chip in the solution with a pH level of 3 dissolved the most with it dissolving 32.60% of its original shell. With the calcium carbonate chips put in the pH levels of 5, 7, 9, and 11 only dissolving at 3.20%, 2.20%, 1.40%, and 0.60%, respectively. This supports the hypothesis with a decreasing trend.

Data Cont'd.


Effect of pH of Water on Calcium Carbonate Shell - Average
Average
30
20
10
0
Difference in Mass of Shell (in %)
pH Level 3
pH Level 5
pH Level 7
pH Level 9
pH Level 11
pH Level of Water

Data Analysis Cont'd.

On **average**, the calcium carbonate chip in the solution with a pH level of 3 dissolved the most with it dissolving 28.96% of its original shell. With the calcium carbonate chips put in the pH levels of 5, 7, 9, and 11 only dissolving at 2.92%, 2.00%, 1.16%, and 0.44%, respectively. This supports the hypothesis with a decreasing trend provided by the data.

Conclusion

- The **research question** was: “What is the effect of changing the pH of water (3, 5, 7, 9, and 11) on calcium carbonate shells of organisms that live in aquatic bodies?”
- The **hypothesis** was: “If the researcher was to test different pH’s of water (3, 5, 7, 9, and 11) to measure the one that would dissolve the most from a calcium carbonate shell, then the water with a pH level of 3 would dissolve the most amount of shell.”
- The hypothesis was **supported** by the data. The water with the pH level of 3 dissolved the most calcium carbonate material, with a difference of 28.96% from the original shell, on average.

Conclusion Cont'd.

- This experiment worked out the way it did for various reasons. As the pH level decreases and becomes more acidic, the dissolving rate of the $CaCO_3$ material increases due to the decrease in hydrogen ion concentration. Carbonate ions are essential to the structure of $CaCO_3$ shells. As water becomes acidic, the number of carbonate ions decrease. Therefore, as the pH level decreases, the $CaCO_3$ shells will dissolve faster.

Conclusion Cont'd.

- There were several errors that could have occurred during the experiment. One error is the volume of the solutions was not precisely measured. This error could be fixed by using a machine or robot to pour the exact amount of liquid into each jar every time. Another error that could have occurred is the mass of the calcium carbonate chips was not accurately measured each time. This error could be prevented by using a more accurate machine to calculate the mass of each chip.

Conclusion Cont'd.

- There are many ways that this experiment could be changed for the future. One way is by testing the same pH levels, but with different solutions to further research ocean acidification. Another way it could be done is by changing the amount of CO_2 that is being exposed to the shells to simulate its effects on aquatic animals.
- This experiment is beneficial to many experts studying about the global problem of ocean acidification. This is because it will show them its negative effects, like an unbalanced food web, a decrease in population, or an unbalanced ecosystem.

Thank You

Are there any questions?

Bibliography

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