How does air temperature affect relative humidity levels?

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THE GLOBE PROGRAM
Global Learning and Observations to Benefit the Environment

Abstract

The research question, *"How does air temperature affect relative humidity levels?"*, is important because variations in relative humidity can influence human health, material longevity, and overall comfort. Relative humidity is a measure of the amount of moisture in the air relative to the air temperature. It was hypothesized that as air temperature increases, relative humidity would also increase, since warmer air promotes greater evaporation and higher absolute humidity. To test this hypothesis, temperature and relative humidity data provided by the *Weather Mate* app were analyzed and compared.

The results showed that as air temperature increased, relative humidity decreased, and as air temperature decreased, relative humidity increased. Additionally, regions with higher average temperatures, such as Florida and California, exhibited lower relative humidity levels. These findings reject the original hypothesis. This outcome is consistent with atmospheric principles, as warmer air has a greater capacity to hold water vapor; therefore, even with increased absolute humidity, the relative humidity may decrease as temperature rises.

Research Question

The question "*How does air temperature affect relative humidity levels?"* is an important question because it shows the relationship between air temperature and relative humidity levels which is important to goods like food and pharmaceutical drugs. The relationship is important for understanding climate change and how rising temperatue may alter humidity levels. This study helps prove how the atmosphere behaves. This question is clearly stated and can be tested scientifically by measuring air temperature and relative humidity using standard weather instruments.

Introduction

The research question allows for an understanding of the effect of air temperature and other environmental factors on relative humidity. This is important for multiple reasons, such as its impact on the long-term storage of goods like food and pharmaceutical drugs.

Studies on this topic describe how and why relative humidity is affected by different temperatures. Other studies also show the correlation between relative humidity and environmental factors such as pressure, surface types, and pollution.

The studies that have been conducted show that relative humidity decreases as temperature increases, and vice versa. This occurs because warmer air can hold more moisture due to having more kinetic energy, which allows water in the air to remain in vapor form. However, when energy is lost and the air becomes cooler, water molecules condense, reducing the amount of water vapor the air can hold. Because relative humidity measures how much water vapor the air holds relative to its temperature, warmer air will have a lower relative humidity than cooler air, even if both contain the same amount of moisture.

Other studies show how additional factors may affect relative humidity. Areas with higher air pressure tend to have higher relative humidity because this air is cooler and denser; therefore, higher-pressure air can have a greater relative humidity than lower-pressure air even with the same amount of water vapor. The surface of an environment also impacts relative humidity, as surfaces with greater moisture content, such as swamps, can release more water vapor into the air compared to dry deserts. Lastly, human activities such as the burning of fossil fuels release greenhouse gases that increase temperature, which in turn decreases relative humidity.

Humidity is a measure of how much water vapor is in the air.

Temperature and Air's Capacity to Hold Water Vapor: The amount of water vapor in the air is influenced by air temperature, as temperature directly affects how much water vapor air can hold. Warmer air holds more water vapor than cooler air, and relative humidity can decrease as temperature increases.

Relative Humidity: This shows how much moisture the air actually contains compared to the maximum amount it could hold at a specific temperature and is the most commonly used humidity measurement.

Evaporation: The process by which liquid water changes into water vapor. As temperature rises, evaporation increases, releasing more water vapor into the atmosphere.

Condensation: The result of cooling warm, humid air to the point where it can no longer hold all water vapor molecules, causing the formation of water droplets.

Environmental Conditions: Vegetation, the presence of water, surface materials, and sunlight exposure can affect both temperature and humidity. For example, shaded or vegetated areas may have cooler temperatures and higher humidity compared to dry, exposed areas.

Research Methods

Planning Investigations

Describes the planning process

Testing:
The "Weather Mate" app will be used on mobile phones to record data from four different locations. This will include air temperature and relative humidity.

Independent Variable:
Air temperature

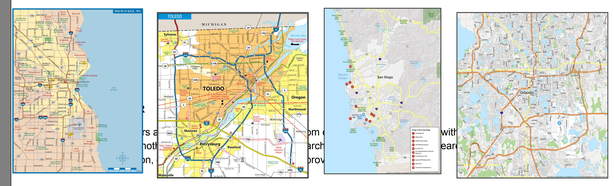
Dependent Variable:
Relative humidity

Control Variables:
Data source (Weather Mate), time for each data point (hour and date), and locations (Toledo, OH; Milwaukee, WI; San Diego, CA; Orlando, FL)

Procedure:

1. Obtain a charged Apple iPhone.
2. Open the iPhone and download the Weather Mate app.
3. Open the Weather Mate app.
4. Record air temperature data from multiple days using the app.
5. Scroll down to find the relative humidity percentage for that area.
6. Record the data on globe.gov in the data analysis tab.
7. Continue recording data for Toledo, OH; Orlando, FL; Milwaukee, WI; and San Diego, CA.

Data Collection and Analysis:
To collect data, air temperature and relative humidity will be recorded using the "Weather Mate" app from present and previous dates. To analyze the data, it will be graphed as a scatter plot, which will show both the strength of the correlation between the two variables and how they relate to one another.



GLOBE Badges

We ARE GLOBE RESEARCHER'S

All participants who submit a project to the VSS receive an "I am a GLOBE Researcher" badge. As such, participants can earn up to four badges total.

We are **Data Scientist's**

The report includes in-depth analysis of students' own data as well as other data sources. Students discuss limitations of these data, make inferences about past, present, or future events, or use data to answer questions or solve problems in the represented system. Consider data from other schools or data available from other databases.

We are Earth System Scientists

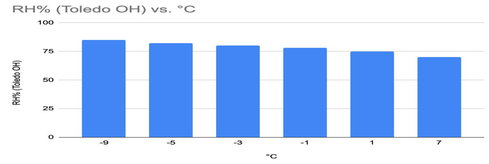
The project clearly describes the interconnectedness of Earth's spheres on the research question and applies multiple GLOBE protocols, or GLOBE Protocol Bundles, to investigate the research question. The research team clearly explains the dynamic and interconnected nature of Earth's systems and the processes that influence and depend on one another through the analysis and interpretation of GLOBE and Earth system science data.

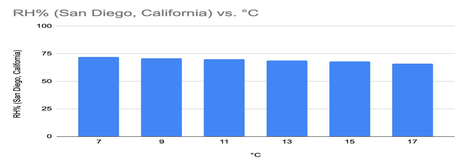
I AM A COLLABORATOR

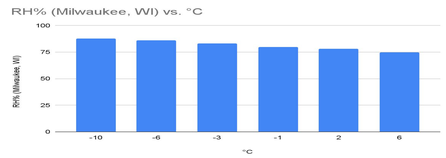
All research team members are listed including collaborators from other organizations, along with clearly defined roles, how these roles support one another, and descriptions of each researcher's contribution. If the researchers collaborated with others outside of their organization, describe how the collaboration improved the research.

Results

°C	RH% (Toledo OH)	°C	RH% (Orlando, FL)	°C	RH% (Milwaukee, WI)	°C	RH% (San Diego, California)
-9	85	2	78	-10	88	7	72
-5	82	4	77	-6	86	9	71
-3	80	6	76	-3	83	11	70
-1	78	8	75	-1	80	13	69
1	75	10	74	2	78	15	68
7	70	12	73	6	75	17	66







Results:

The data shows a decrease in relative humidity percentage as the temperature increased. This is seen throughout all 4 different environments, as the bars are clearly shown decreasing as temperature increases. The data also shows each relative humidity percentage per the temperature it at in the various cities allowing us to easily analyze the relationship between temperature and relative humidity. The relationship being, as temperature increases relative humidity percentage decreases.

Discussion

The results found that as air temperature increases, relative humidity decreases. These results were obtained through multiple trials from different cities, including Toledo, OH; Orlando, FL; Milwaukee, WI; and San Diego, CA. This allowed for the research of a wide range of data and observation of how, as air temperature increases, relative humidity percentage decreases, creating a strong understanding of the relationship between the two variables.

Other studies from sources such as the National Weather Service have found that relative humidity decreases as air temperature increases. They state that when the amount of water vapor in the air remains constant, warmer air has a greater capacity to hold water, so even when the amount of vapor does not change, the relative humidity decreases. Additionally, information found from Vaisala explains that rising air temperature causes the air to become drier, which leads to a decrease in relative humidity, because relative humidity is a measure of how much water vapor is in the air compared to how much the air can hold.

The hypothesis was not supported by the results because it stated that as air temperature increases, relative humidity levels increase as well. Although warm air can hold more vapor, relative humidity levels actually decreased, as observed in the experiment. The results were not what was initially expected to be recorded, since it was thought that when temperature increases, relative humidity percentage would also increase; however, this was not the case.

These results were obtained because as temperature increases, the air can hold more water, so when maintaining a similar vapor content, the relative humidity decreases. Likewise, when temperatures are colder and absolute humidity stays the same, relative humidity increases since cold air has a lower capacity to hold water. Other factors may also play a role, as higher air temperatures allow water to evaporate more easily, while colder temperatures cause water vapor to condense more easily.

A few experimental errors faced while recording data included not recording at the same exact time each day. This could have impacted the results since sunlight may play a role in temperature and water vapor levels. If the experiment were to be redone, it could be improved by taking data at the exact same time each day to create a closer range of data for analysis.

The experiment accurately tested the hypothesis, although the hypothesis was not supported. The hypothesis was tested by using different locations and environments (Toledo, Milwaukee, Orlando, and San Diego) as trials and by comparing the air temperatures of each location to observe the correlation between air temperature and relative humidity. Overall, the hypothesis was tested accurately, but it was not supported since it stated that relative humidity increases as temperature increases.

Conclusions

The hypothesis was rejected because it stated, *"If the air temperature of an area increases, then the relative humidity levels also increase because warmer air has a greater capacity to hold water vapor."* This statement is partially correct because warmer air has a greater capacity to hold water vapor; however, it incorrectly stated that relative humidity levels increase in correlation with increasing air temperature, which was found to be false in the experiment.

A few successes of the experiment were the ability to accurately record data that corresponded to different locations, which allowed for a wider range of data along with multiple trials. It was also accurately determined that relative humidity decreases as temperature increases, which corresponds to other studies that have demonstrated similar experiments.

Potential changes to the experiment would include recording data from similar time ranges rather than using widespread data. Data were recorded only during daytime hours, but it would be important to have a specific and exact time range, as results can be affected by a variety of factors such as the sun. It may also be beneficial to test humidity percentage instead of relative humidity and to take dew point into account, as it represents a different measurement that can still impact the experiment.

There were a few areas that required further investigation during the experiment. Some questions that arose included, *"What is relative humidity?"* and *"How does relative humidity differ from absolute humidity?"* Another question considered was how to collect data from a wide range of locations to improve accuracy. These questions were researched before and during the experimental phase, relative humidity was clearly defined, and locations with varying climates were selected, such as a tropical climate in Orlando, Florida.

This research is important because it helps support what other studies have found. It helped develop a clear correlation between air temperature and relative humidity percentage. Since it was found that as temperature increases, relative humidity decreases, the experiment aligns with what many scientists have demonstrated. These findings can help scientists better understand the relationship between air temperature and relative humidity and determine appropriate adjustments for air temperature so that products such as medicine, food, and systems remain functional and efficient.

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