Impact of Air Temperature on Relative Humidity - A study

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Air temperature and Humidity are important property of the urban climate that has implications in areas related to human comfort and health. They are essential components of a comfortable environment. The aim of this study is to understand the relationship between air temperature and its moisture holding capacity and thus its effect on Relative Humidity. From the study it has been statistically proved that the moisture holding capacity of air depends on the air's temperature. It increases with increase in temperature. As the moisture holding capacity increases the relative humidity decreases, provided no moisture is added to the air. This conclusion will help in better understanding of the relationship between temperature and moisture holding capacity of the air and relative humidity.

All climatic variables like air temperature, humidity etc. are affected by each other (Givoni B. 1976). The air temperature variation brings about a change in water evaporation and air saturation, leading to the change in air humidity. Furthermore, the air temperature differences between different locations will also cause air pressure differences, which in turn would produce air movement, thereby wind. This variation in humidity and wind speed and direction affects rainfall. Thus, all weather variables on the Earth are more or less affected by each other. This correlation can be easily explained by the flow diagram shown below -

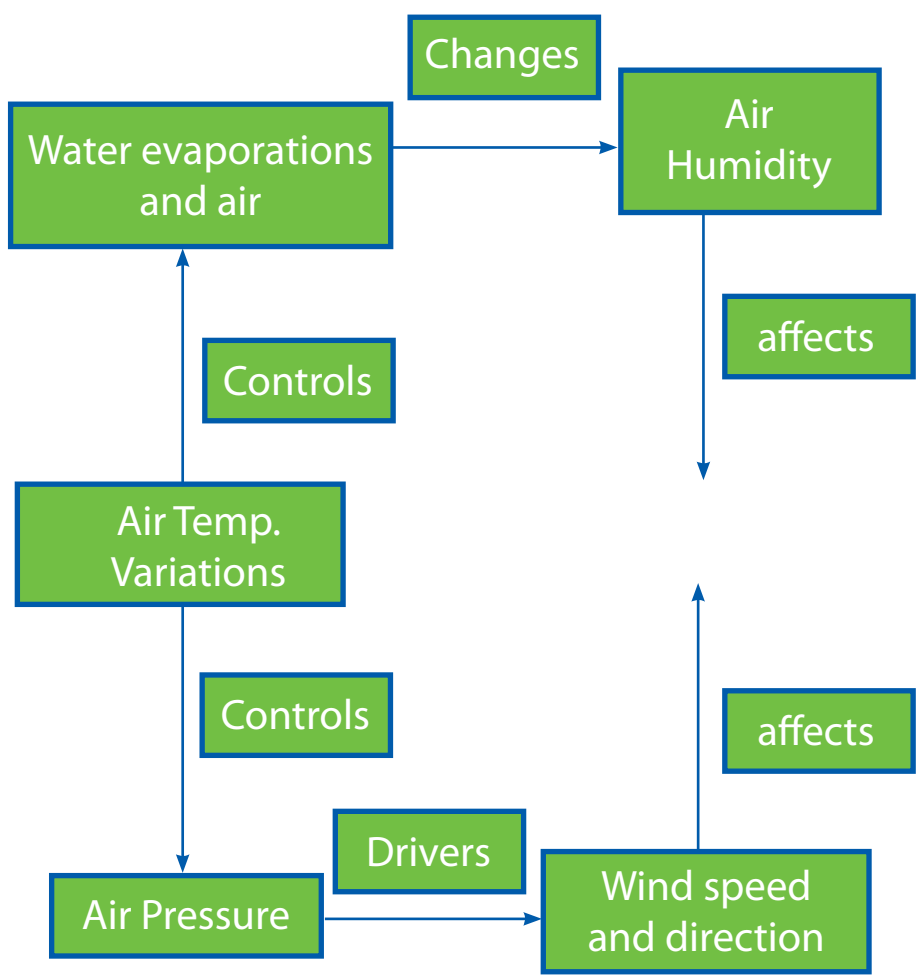


Fig 1 Climatic variables and their correlation

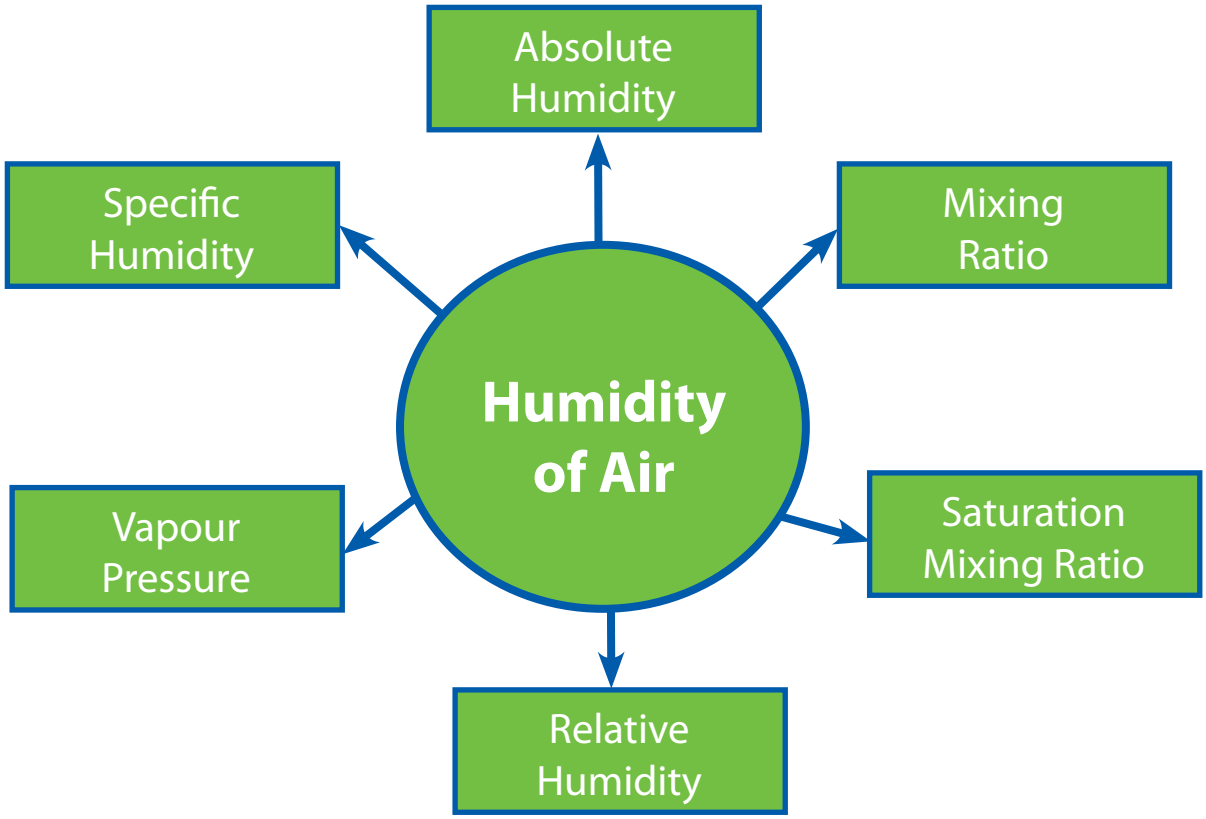


Fig 2- Various ways of expressing humidity

HUMIDITY IN THE AIR

Water is an extremely pervasive substance and can be found everywhere on the planet—including the air, where it's held as vapour. The term humidity describes the fact that the atmosphere can contain water vapour. Humidity is the quantity of water vapor present in air. There are many and varied ways of expressing it. It can be expressed as an absolute, specific or a relative value.

MEASURES OF HUMIDITY

There are several ways to describe the humidity of air which is shown in Fig.2

Absolute Humidity - expresses the water vapor content of the air using the mass of water vapor contained in a given volume of air. It may be measured in grams of vapor/cubic meter of air. A problem with using absolute humidity is that an air parcel changes volume as the ambient temperature and pressure change. This means that the absolute humidity changes when the volume changes, even though the mass of water vapor has not changed.

Specific Humidity - measures the water vapor content of the air using the mass of the water vapor for a given mass of air. It may be measured in grams of water vapor per kilogram of air. The kilogram of air measured includes the water vapor present (compare this to mixing ratio, below). Unlike absolute humidity, specific humidity doesn't change as the air parcel expands or is compressed.

Mixing ratio - In meteorological measurements, mixing ratio is usually expressed in grams of water vapor per kilogram of dry air. Since mixing ratio measures the mass of water vapour for a given mass of dry air it is not affected by changes in pressure and temperature.

Saturation Mixing ratio - Saturation mixing ratio refers to the mass of water vapour that can be held in a kilogram of dry air at saturation.

The data in Table 1 indicates that warmer air has a higher saturation mixing ratio than cooler air at a constant atmospheric pressure. It is important to note that this relationship between temperature and water vapour content in the air is not linear but exponential. In other words, for each 10° increase in temperature, saturation mixing ratio increases by a larger quantity.

Vapour Pressure - measures the water vapour content of the air using the partial pressure of the water vapour in the air. The gases in the atmosphere exert a certain amount of pressure. The vapour pressure of the water in the air at sea level, at a temperature of 20 degrees C, is 24 mb at saturation.

Table 1: Saturation mixing ratio (at 1000 mb-millibars). (at average sea level pressure)

(Source- Fundamentals eBook- Introduction to the hydrosphere)

Temperature Degrees Celsius	Vapor (g) per Kilogram of Dry Air
50	88.12
40	49.81
30	27.69
20	14.85
10	7.76
0	3.84

Relative humidity - The most commonly used measure of humidity is relative humidity. Relative humidity can be simply defined as the amount of water in the air relative to the saturation amount the air can hold at a given temperature multiplied by 100.

$$\text{Relative humidity} = \frac{\text{The actual amount of water vapour in the air}}{\text{X}} \times 100\%$$

The amount of water vapour required to saturate the air at that temperature

Relative humidity is directly related to the amount of water vapor in air, and that's the relationship. The more is the water vapour in the air, the higher the relative humidity is at a given temperature. Air with a relative humidity of 50% contains half of the water vapor it could hold at a particular temperature.

METHODOLOGY

To statistically prove the effect of change in temperature on the relative humidity of air, the temperature and Relative Humidity is recorded at a fixed place at a interval of three hours. A place is fixed so that there is no change in the moisture content of the air. Variation in temperature with time and thus the variation in Relative Humidity is recorded.

INSTRUMENT FOR MEASURING RELATIVE HUMIDITY AND TEMPERATURE

Name of Instrument - 4 in 1 Professional Instrument LUTRON LM-8000

The selection of the instrument to take the readings was based on the following factors-

- Accuracy of readings
- Handy

Specification: LUTRON LM-8000

- 4 in 1 professional measuring instrument: Anemometer, Hygrometer, Thermometer and light meter.
- Tiny bone shape with lightweight and small size case design are suitable for handling with one hand.
- Wristlet design provides extra protection to the instrument especially for user one hand operation.
- Low- friction ball vane wheels design provides high accuracy at high and low air velocity

Fig 4 - 4 in 1 Professional Instrument LUTRON LM-8000

TABULATION OF THE DATA COLLECTED

Table 2 – On site measurement of Temperature and Relative Humidity

Time	Temperature °C	Relative Humidity %
03:00	20.2	66.3
06:00	22.6	64.7
09:00	23.8	55.4
12:00	26.1	43.6
15:00	30.2	41.1
18:00	25.7	56.3
21:00	24.9	61
24:00	22.5	65.4

OBSERVATIONS AND DISCUSSION

From the above graph it is clear that as the temperature increases there is fall in relative humidity and when the temperature goes down the relative humidity goes up.

Relative humidity varies significantly when the temperature changes, even when the actual amount of water vapour in the air remains the same.

Given that the amount of water vapor is held constant, then if there is-

-- reduction in the temperature, the relative humidity goes up

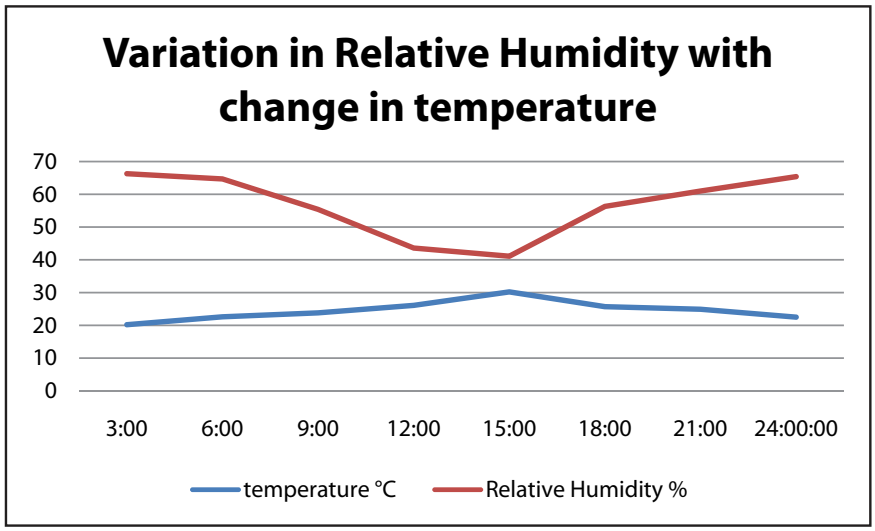
-- increase in the temperature, the relative humidity goes down.

CONCLUSIONS

Relative humidity depends on two factors: the amount of moisture available, and on the temperature.

So you can have a change in relative humidity in one of two ways:

1) Change the amount of water vapour available; if there is liquid water present, for instance, a lake, you can have an increase in relative humidity by evaporation from the surface of the lake. This is because with the increase in water vapour, the humidity increases.
2) The other way is to change the tem-



perature of the air, while holding the water vapour constant. Even though there is no water source, and no water vapour is added, a lowering of air temperature results in a rise of relative humidity. The amount of water vapor that could be present at saturation is less at the lower temperature, so the existing amount of water vapor represents a higher percentage of the saturation level of the air. Similarly, a rise in temperature results in a decrease in relative humidity, even though no water vapor has been taken away.

The moisture holding capacity of air depends on the air's temperature. It increases with increase in temperature. As the moisture holding capacity increases the relative humidity decreases, provided no moisture is added to the air.

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