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EXPLAINED

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Scorching heat: A vendor sells monkey pod, a summer fruit also known as ‘seema chintakaya’ by the locals, in Vijayawada, April 21, 2023. | Photo Credit: Giri K.V.S./The Hindu

Relative humidity is a simple concept as weather phenomena go – but it has significant, far-reaching consequences for how we must take care of ourselves on a hot or wet day.

Humidity is the amount of moisture in the air around us, and there are three ways to track it. The most common of them is absolute humidity: the mass of water vapour in a given volume of the air and water vapour mixture, expressed as kg/m3. The second is specific humidity, equal to the mass of the moisture divided by the mass of air. It is expressed as a dimensionless number (but sometimes also as grams per kilogram, among other similar units.)

The third way is relative humidity: it is important because it factors in the amount of vapour that air can hold at different temperatures. Determining its value is a bit more complicated: it is the vapour density of the air divided by the saturation vapour density at the dry-bulb temperature.

On a hot day, our body uses sweat to cool itself. Sweat is released via our skin to the surface. There, the liquid evaporates. When water changes phase from liquid to vapour, it absorbs heat from the surface on which it lies. So when sweat evaporates, it absorbs heat from the skin, cooling it.

The higher the relative humidity of air, the more it is filled with moisture. When air already contains a lot of moisture, it won’t easily accept more. This means that the sweat on your skin can’t evaporate. At the same time, the body keeps sweating because it is still expecting to cool itself.

As a result, if the relative humidity is high, you can sweat on a hot day even when you are sitting still – while your body also keeps accumulating heat. This can quickly become dangerous.

A relative humidity of 30-60% is generally considered to be comfortable. Environments that have lower levels than this typically use humidifiers to increase the humidity. When the level is higher, a fan will help move the air around you and help sweat evaporate better.

In both cases, drinking water is important.

Warmer air can hold more moisture than cooler air. So at the same absolute humidity, the

relative humidity of warmer air will be lower than that of cooler air. It is like saying two vessels can hold the same amount of water – just that the bigger vessel will be less full than the smaller vessel.

This is why, for example, while Chennai had an absolute humidity of 70% at 2.30 pm on April 23, its relative humidity was lower, around 60%, because it had an ambient temperature of 32 C.

The change in the capacity for moisture as the air warms is also non-linear, meaning it doesn't increase by the same amount as the air warms. For example, the difference as it warms over 20º C from -20º C to 0º C is small, but there is an enormous improvement in its vapour-carrying capacity as it warms over 20º C from 30º C to 50º C.

There are a few ways to measure relative humidity. One is to conduct a simple experiment with household items; another is to use maths; a third is to use an app or device.

Experiment

For the experiment, you need two mercury thermometers, some cotton, rubber bands, and access to cold water.

First, make sure both thermometers show the same reading, say, under a fan. Next, soak some cotton in cold water and wrap it around the bulb of one of the thermometers with a rubber band. Hold this thermometer under the fan, such that water from the cotton evaporates, and record the thermometer reading after five minutes. Hold up the other thermometer in the air and record its reading after five minutes. You will thus have the wet-bulb and dry-bulb temperatures, respectively.

Next, subtract the wet-bulb temperature from the dry-bulb temperature to get the temperature difference. Finally, use the relative humidity chart (see below) to get the relative humidity value. For example, if the difference was 6 C and the dry-bulb temperature was 28 C, the relative humidity would have been 59%.

A psychrometer is a device that has two such thermometers plus a chart to get the final reading. Modern, electronic psychrometers can calculate the relative humidity directly.

For a rough sense, the lower the wet-bulb temperature, the drier the air is, and the less relatively humid it is.

Mathematics

There are two mathematical ways (among others) to estimate the relative humidity, one simpler and one a bit more involved.

The first way is to divide the actual vapour pressure by the saturated vapour pressure. The vapour pressure is the amount of moisture that air contains. The 'saturated' value is the maximum possible amount. The formula (below) requires the dew point (Td), which you can obtain from a weather website.

$R_H = (e/e_s)*100$

$e = 6.11 \times 10^{((7.5 \times Td)/(237.3 + Td))}$

For e_s, use the same formula but replace Td with T, the actual temperature.

The second way is to calculate relative humidity starting from the specific humidity, pressure and temperature, using the Clausius-Clapeyron equation.

App

If you prefer software: Search for “hygrometer” in your phone’s app store to locate some options. (A hygrometer is an instrument that measures humidity.) Note that the app will only work if your phone has a sensor that can sense humidity.

If you like hardware, psychrometers and devices called hygrometers are available in physical as well as online stores.

The relative humidity reading according to an app somewhere in Chennai on April 24, 2023, at 1:45 pm. | Photo Credit: Hygro

This said, a more direct way to understand the implications of the relative humidity for your wellbeing is in the form of the wet-bulb temperature (a.k.a. the adiabatic saturation temperature). It is the lowest temperature a surface – like your skin – can reach when water evaporates from it. The wet-bulb temperature is equal to the dry-bulb temperature when the relative humidity is 100%.

A wet-bulb temperature in an environment of 32-35º C or higher can be quickly lethal, even if you are not doing any physical activity or are in the shade. (At least one study has shown that even a wet-bulb temperature of more than 29º C can be dangerous.)

The climate crisis is rendering heatwaves more common, more frequent, more spread out, and more potent over the Indian subcontinent. As a study published in May 2022 put it:

“Whether today’s most impactful heatwaves could have occurred in a pre-industrial climate, traditionally a central focus of attribution research, is fast becoming an obsolete question. The next frontier for attribution science is to inform adaptation decision-making in the face of unprecedented future heat.”

One way to adapt is to keep an eye on the relative humidity, drink lots of water, and cool yourself.

END