November 6, 2017

Environmental Science

Environmental Monitoring Guide:

Parameter: Humidity

University of Aruba- FHTMS

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About this guide

This is a guide to humidity measurement created by students of the FHTMS faculty at the University of Aruba. This guide investigates the air quality; specifically relative humidity status of the University of Aruba. The aim of the assignment is to measure and observe the possible influence of humidity on our surroundings. The instruments used to collect the data is the DHT22 sensor and the Arduino Uno Board. Results indicate that the relative humidity inside Classroom A and relative humidity outside are noticeably different due to the air-conditioning system (relative humidity rises when temperature falls). Additionally, the results of the fieldwork done at the Parkietenbos landfill has been recorded, typed into a spreadsheet, observed and compared to the values of the University of Aruba done the previous week. The average measurements for both sites were calculated, analyzed and scientifically interpreted by our group members. The health impacts linked to high temperatures and relative humidity has also been researched and discussed in detail in this paper.

Contents

Introduction

What is Humidity?

Humidity is the amount of water vapor in the air. It can also be described as a hot and sticky feeling. The higher the humidity, the wetter it feels outside. Humidity is most commonly used to describe how we feel, usually paired up with heat: if it's hot and humid outside, one is most likely to feel very uncomfortable. This is because the body tries to cool itself through evaporation of moisture on the skin (sweat), but when the air is humid, the moisture becomes more difficult to evaporate and makes the cooling effect decrease.

According to Jeffrey Hovis, scientifically, "the term humidity is the amount of water vapor in the atmosphere. The vapor pressure of water measures the amount of water vapor in the air (humidity). The saturation vapor pressure is the vapor pressure when liquid water begins to condense." (Scientific American).

Relative humidity is determined by using the actual vapor pressure divided by the saturation vapor pressure. It is expressed as the percentage of the amount needed for saturation at the same temperature. For example, if the relative humidity is 100%, the air is said to be completely saturated (which results in precipitation). If the relative humidity is 50%, the air contains half the water vapor required for it to be saturated. If the amount of water vapor in the air increases, the relative humidity increases, and if the amount of water vapor in the air decreases, the relative humidity decreases.

Relative humidity is an important metric and most commonly used in weather forecasts and reports, as it is an indicator of the likelihood of precipitation, dew, or fog. For instance- on

Aruba, the relative humidity is high, this increases the thermal environment, which in turn increases the apparent temperature of humans (as well as plants and animals) by hindering the evaporation of perspiration from the skin.

The dew-point temperature (dew) is also used by meteorologists to measure the amount of water vapor in the atmosphere. This is can be described as when the atmosphere becomes saturated with water vapor. When the air reaches the dew-point temperature at a certain pressure, it can be said that the water vapor in the air is in equilibrium with liquid water, meaning water vapor is condensing at the same rate at which liquid water is evaporating.

Why is it important?

As aforementioned, Humidity is a measure of the amount of moisture in the air. It affects many properties of air (gives rise to clouds, rain, snow, dew, frost and fog), and of materials in contact with air (humans, animals, plants etc.). Humidity has a large impact on human and animal health, and the health of crops. It is important because it affects the ability of both plants and animals to cool themselves through evaporation.

Water vapor is a key agent in both weather and climate, and is an important Atmospheric Greenhouse gas. A huge variety of manufacturing, storage as well as testing processes are Humidity-critical. Humidity measurements are used wherever there is a need to prevent condensation, corrosion, mold, warping or other spoilage of products. It is important to understand this when trying to rule out why mold is growing on one patch of wall or only along the wall-ceiling joint. It is likely that the wall is cooler than the room air because there is a void in the insulation or because wind is blowing through cracks in the exterior of the building

Humidity is also highly relevant for foods (agriculture), pharmaceuticals, chemicals, fuels, wood, paper, and many other products we consume. Humidity measurements contribute primarily to achieving correct environmental conditions to sustain life.

Humidity on Aruba

The following tables illustrate the data collected by the Aruban Meteorological Department;

As seen in the figure below, the average dew-point temperature for the period 1981-2010 was usually the lowest in the months of January to March (average 22 – 22.5°C) and the highest between May and November (average 24 – 24.6°C). The yearly average dew-point temperature was 23.7°C for the period 1981 – 2010. The yearly relative humidity was 77.4% for the period

DEPARTAMENTO METEOROLOGICO ARUBA **SUMMARY CLIMATOLOGICAL NORMALS, PERIOD 1981 - 2010**

Beatrix Airport Aruba (12°30'N, 70°01'W)

Element	UNIT	JAN	FEB	MRT	APR	MEI	JUN	JUL	AUG	SEP	OKT	NOV	DEC	YEAR
Air temperature	°C	26.7	26.8	27.2	27.9	28.5	28.7	28.6	29.1	29.2	28.7	28.1	27.2	28.1
Av. max. temperature	°C	30.0	30.4	30.9	31.5	32.0	32.2	32.0	32.6	32.7	32.1	31.3	30.4	31.5
Abs. max. temperature	°C	32.5	33.0	33.9	34.4	34.7	35.2	35.2	36.1	36.5	35.4	34.2	33.3	36.5
Av. min. temperature	°C	24.5	24.7	25.0	25.8	26.5	26.7	26.4	26.8	26.9	26.4	25.8	25.0	25.9
Abs. min. temperature	°C	21.3	20.6	21.4	21.9	23.2	22.8	21.6	21.3	22.1	21.9	22.0	21.4	20.6
Av. wetbulb temperature	°C	~	~	~	~	~	~	~	~	~	~	~	~	~
Av dew-point temperature	°C	22.4	22.2	22.5	23.4	24.2	24.4	24.3	24.4	24.6	24.6	24.1	23.1	23.7
Seawater temperature	°C	~	~	~	~	~	~	~	~	~	~	~	~	~
Air pressure * (+1000)	mb	13.0	12.9	12.3	11.5	11.3	12.1	12.6	11.6	10.8	10.4	10.5	12.1	11.8
Vapor pressure	mb	27.2	26.8	27.3	28.9	30.3	30.5	30.4	30.6	31.1	30.9	30.0	28.3	29.4
Relative Humidity	%	77.5	76.1	75.7	77.1	77.9	77.4	77.8	76.2	76.8	78.6	79.1	78.4	77.4
Monthly rainfall	mm	39.3	20.6	8.7	11.6	16.3	18.7	31.7	25.8	45.5	77.8	94.0	81.8	471.7
Hours with rainfall		41.8	24.1	11.1	9.2	11.8	13.5	25.4	16.5	17.3	31.6	51.3	52.6	291.0
Days with rainfall ≥ 1.0 mm		8.4	5.0	1.8	1.9	2.2	2.8	4.9	4.3	3.9	7.4	10.6	11.4	64.6
Highest rainfall in 24 hrs.	mm	47.8	43.0	59.0	35.5	78.7	62.5	78.8	34.6	196.6	101.6	126.0	71.8	196.6
Days with thunder		0.0	0.0	0.0	0.1	1.1	0.8	2.1	2.0	3.3	6.1	2.8	0.6	17.9
Cloud Coverage	%	36.8	38.0	40.7	51.7	54.1	52.0	50.3	45.9	50.3	53.4	50.4	44.2	47.3
Sunshine duration	%	~	~	~	~	~	~	~	~	~	~	~	~	~
Sunshine duration	hrs	~	~	~	~	~	~	~	~	~	~	~	~	~
Wind direction	deg													
Wind speed	m/s	7.0	7.6	7.7	7.7	8.0	8.7	8.1	7.8	6.8	5.8	5.8	6.4	7.3
Av. max windspeed	m/s	14.3	15.0	14.9	14.9	15.0	16.2	15.8	15.1	13.8	12.6	12.7	13.6	14.5
Strongest windgust	m/s	21.6	22.6	21.9	20.0	21.1	21.4	28.8	23.0	22.6	21.1	20.6	19.5	28.8
Pesistency of the wind	%	~	~	~	~	~	~	~	~	~	~	~	~	~

x) 1000 mb should be added to these values 1 knot= 1.151 mph= 1.85 km/h=0.514 m/sec ~ Meaning data not Available

1981 – 2010. The relative humidity was consistent throughout the year, with the highest relative

humidity recorded was 79.1% for the month of November, and the lowest was 75.7% for the month of March.

The figure below illustrates a summary of climatological data for the year 2016. The yearly average dew-point temperature was 24.0 °C, with the lowest dew-point temperature recorded in the months of January to March (22 – 22.4°C) and the highest in the months of August and September (25.3. – 25.8°C)

METEOROLOGISCHE DIENST ARUBA **SUMMARY CLIMATOLOGICAL DATA 2017**

		JAN	FEB	MRT	APR	MEI	JUN	JUL	AUG	SEP	OKT	NOV	DEC	YEAR
Air temperature	°C	26.5	27.1	27.8	28.7	29.1	29.1	29.4	29.8					
Av. max. temperature	°C	29.7	30.6	31.3	32.5	32.7	32.8	33.0	33.7					
Abs. max. temperature	°C	30.8	31.8	32.5	33.4	33.6	33.9	33.9	35.2					
Av. min. temperature	°C	24.3	24.5	25.6	26.7	27.1	27.0	27.2	27.6					
Abs. min. temperature	°C	21.8	21.8	23.4	25.7	25.7	25.3	24.7	26.2					
Av. wetbulb temperature	°C	23.5	23.4	24.2	25.2	25.9	25.9	25.7	26.1					
Av dew-point temperature	°C	22.2	21.8	22.7	23.9	24.7	24.8	24.4	24.7					
Seawater temperature	°C	27.2	26.6	26.9	~	~	~	~	~	~	~	~	~	~
Air pressure *	mb	13.6	13.4	12.9	11.4	11.8	12.1	12.6	11.4					
Vapor pressure	mb	26.8	26.1	27.7	29.6	31.2	31.3	30.5	31.2					
Relative Humidity	%	77.7	73.3	74.5	75.3	77.8	77.8	75.1	74.7					
Monthly rainfall	mm	110.8	27.2	6.4	0.0	16.4	20.4	43.0	8.8					
Hours with rainfall		50.0	19.0	13.0	0.0	2.0	14.0	16.0	6.1					
Days with rainfall ≥ 1.0 mm		11.0	3.0	3.0	0.0	1.0	4.0	4.0	3.0					
Highest rainfall in 24 hrs.	mm	21.6	19.2	3.2	0.0	15.8	11.4	15.0	4.4					
Days with thunder		0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0					
Cloud Coverage	%	50.8	46.3	63.6	66.9	69.9	64.5	63.6	62.0					
Sunshine duration	%	~	~	~	~	~	~	~	~	~	~	~	~	~
Sunshine duration	hrs	~	~	~	~	~	~	~	~	~	~	~	~	~
Wind direction	deg	082	080	081	087	089	090	088	087					
Wind speed	m/s	5.9	6.7	7.2	8.2	8.2	8.5	8.3	7.4					
Av. max windspeed	m/s	13.9	14.2	14.4	15.6	15.8	16.6	15.9	15.1					
Strongest windgust	m/s	19.5	18.0	20.6	19.5	19.5	20.1	18.0	18.5					
Pesistency of the wind	%	~	~	~	~	~	~	~	~		~	~	~	~

x) 1000 mb should be added to these values 1 knot= 1.151 mph= 1.85 km/h=0.514 m/sec

The table on the following page represents a summary of the climatological data for 2017 (so far). It was last updated in August 2017. The lowest average dew-point temperature so far has been recorded in February (21.8°C) and the highest average dew-point temperature so far has

been recorded in June (24.8°C). The lowest recorded relative humidity was 73.3% in February and the highest relative humidity recorded so far was in May and June (77.8%).

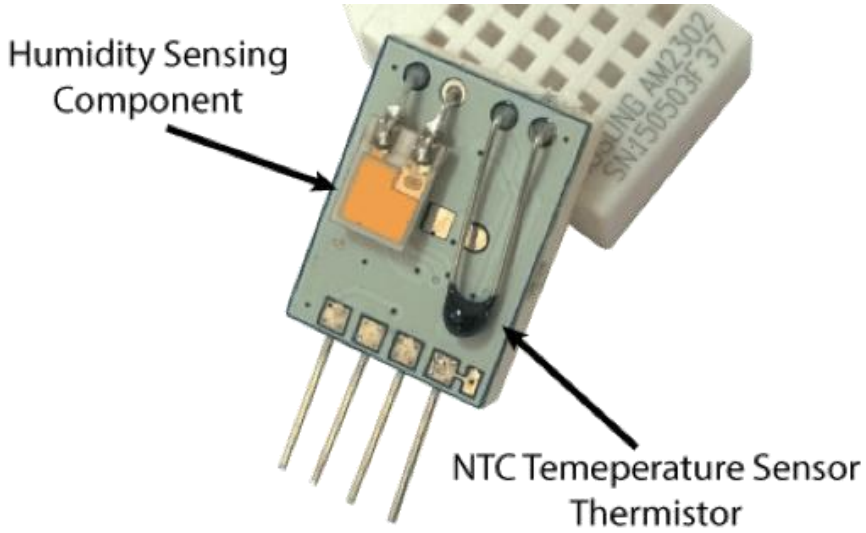
METEOROLOGISCHE DIENST ARUBA **SUMMARY CLIMATOLOGICAL DATA 2016**

		JAN	FEB	MRT	APR	MEI	JUN	JUL	AUG	SEP	OKT	NOV	DEC	YEAR
Air temperature	°C	27.2	27.6	28.1	28.9	29.4	29.5	29.3	29.9	29.9	29.5	28.8	27.8	28.8
Av. max. temperature	°C	30.7	31.1	31.9	32.6	32.9	32.8	32.5	33.5	33.3	32.6	31.8	30.8	32.2
Abs. max. temperature	°C	31.7	31.6	32.5	33.8	35.0	34.3	33.3	35.1	34.8	34.1	33.8	32.8	35.1
Av. min. temperature	°C	25.2	25.7	26.1	26.8	27.7	27.5	27.1	27.9	27.7	27.2	26.5	25.4	26.7
Abs. min. temperature	°C	23.7	24.7	24.2	24.9	26.8	24.5	24.2	26.9	24.6	25.6	23.4	23.5	23.4
Av. wetbulb temperature	°C	22.8	22.8	23.1	24.3	24.7	24.7	24.9	26.5	26.8	26.1	25.6	24.6	24.7
Av dew-point temperature	°C	22.3	22.2	22.4	24.0	24.5	24.3	24.6	25.3	25.8	24.9	24.4	23.4	24.0
Seawater temperature	°C	~	~	~	~	~	~	~	~	~	~	~	~	~
Air pressure *	mb	12.9	12.3	13.2	10.9	11.8	13.1	12.8	11.4	11.3	9.1	9.3	12.3	11.7
Vapor pressure	mb	27.0	26.8	27.2	29.8	30.7	30.4	31.0	32.2	33.2	31.6	30.6	28.7	29.9
Relative Humidity	%	75.5	73.2	71.5	75.4	75.1	74.2	76.3	76.9	79.1	76.7	77.7	77.4	75.8
Monthly rainfall	mm	10.4	0.8	2.6	0.0	0.0	26.6	58.2	1.2	68.3	39.0	130.8	90.0	427.9
Hours with rainfall		12.0	0.0	2.0	0.0	0.0	12.0	28.0	3.0	24.0	10.0	26.0	83.0	200.0
Days with rainfall ≥ 1.0 mm		3.0	0.0	0.0	0.0	0.0	3.0	8.0	0.0	5.0	5.0	10.0	18.0	52.0
Highest rainfall in 24 hrs.	mm	5.0	0.0	0.0	0.0	0.0	19.8	17.4	0.6	32.0	29.0	70.6	14.0	70.6
Days with thunder		0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	4.0	4.0	3.0	1.0	14.0
Cloud Coverage	%	48.4	47.5	54.1	68.5	67.2	62.4	62.0	57.4	59.8	67.6	74.1	60.1	60.8
Sunshine duration	%	~	~	~	~	~	~	~	~	~	~	~	~	~
Sunshine duration	hrs	~	~	~	~	~	~	~	~	~	~	~	~	~
Wind direction	deg	082	080	075	076	083	083	101	090	088	094	105	082	087
Wind speed	m/s	7.3	8.7	8.6	7.8	8.8	9.3	8.3	8.5	7.3	5.1	3.9	6.6	7.5
Av. max windspeed	m/s	14.7	16.6	16.2	15.0	16.2	17.7	16.0	16.2	15.2	11.9	10.6	14.7	15.1
Strongest windgust	m/s	19.5	19.5	20.1	18.5	19.5	22.6	19.5	21.1	17.0	16.4	14.4	19.0	18.9
Pesistency of the wind	%	~	~	~	~	~	~	~	~		~	~	~	~

x) 1000 mb should be added to these values 1 knot= 1.151 mph= 1.85 km/h=0.514 m/sec

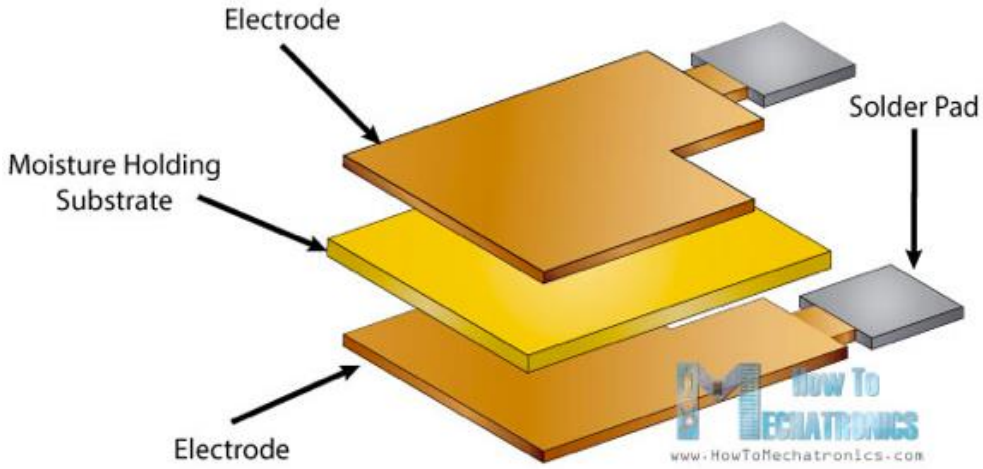
DHT22 Temperature and Humidity Sensor;

The DHT22 Temperature and humidity sensor consists of a humidity-sensing component, a Negative Temperature Coefficient (NTC) temperature sensor (or thermistor) and an Integrated circuit (IC) on the backside of the sensor.

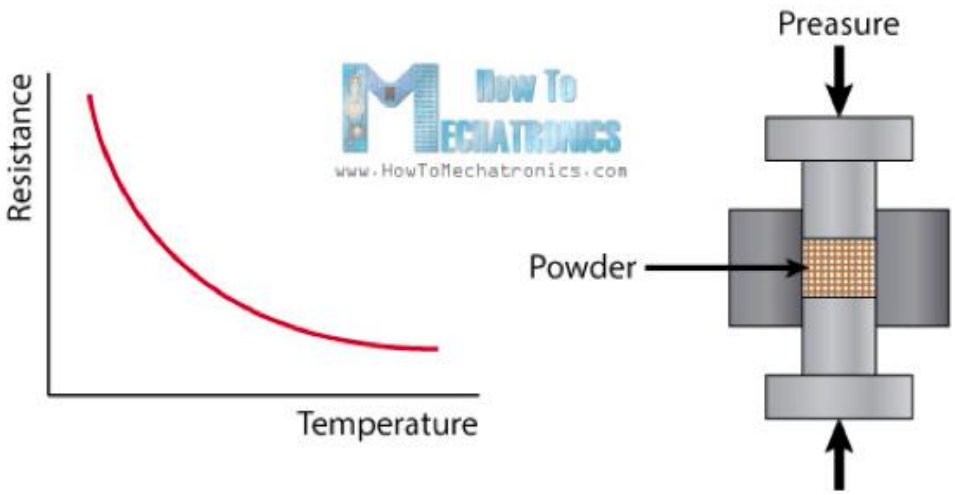


In order for us to measure the humidity at the University of Aruba, the DHT22 uses its humidity-sensing component. This component has two electrodes with moisture holding substrate between them. This is how the sensor actually works:

As the humidity changes, the conductivity; the transferring of thermal energy (heat, temperature) to something else, of the substrate changes or the resistance between these electrodes changes. This change in resistance is measured and processed by the integrated circuit, which makes it ready to be read by a microcontroller.



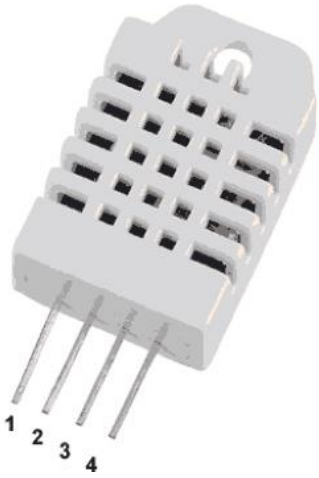
For measuring the temperature the sensor uses the NTC temperature sensor or a thermistor. A thermistor is actually a variable resistor that changes its resistance with change of the temperature. These sensors are made by the process of compacting and forming a solid mass of material by heat or pressure such as ceramics or polymers in order to provide larger changes in the resistance with just small changes in temperature. Negative Temperature Coefficient means that the resistance decreases with increase of the temperature.



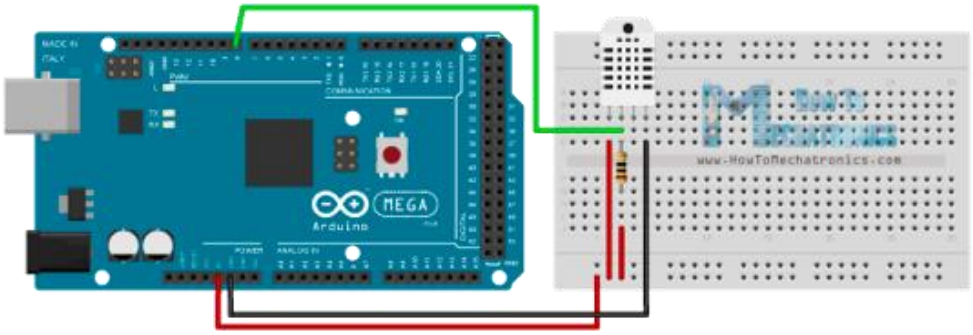
The DHT22 sensor has four pins:

1. VCC (power supply) Power's voltage should be 3.3-6V DC
2. DATA (signal) communication between MCU and AM2303
3. NC (not connected or not available)
4. GND (ground pin plugged in circuit)

DHT22 pins	
1	VCC
2	DATA
3	NC
4	GND



“A pull-up resistor from 5K to 10K Ohms is required to keep the data line high and in order to enable the communication between the sensor and the Arduino board.” (Dejan Nedelkovski, 2017)



The DHT22 sensor has a single wire protocol in order to transfer the data.

The coding used to program the sensor is as follows;

```
// Example testing
sketch for various
DHT
humidity/temperature
sensors
                        // Written by ladyada, public domain

                        #include "DHT.h"

                        #define DHTPIN 2     // what digital pin we're connected to

                        // Uncomment whatever type you're using!
                        //#define DHTTYPE DHT11   // DHT 11
                        #define DHTTYPE DHT22   // DHT 22  (AM2302), AM2321
```

```
//#define DHTTYPE DHT21   // DHT 21 (AM2301)


// Connect pin 1 (on the left) of the sensor to +5V
// NOTE: If using a board with 3.3V logic like an Arduino Due
connect pin 1
// to 3.3V instead of 5V!
// Connect pin 2 of the sensor to whatever your DHTPIN is
// Connect pin 4 (on the right) of the sensor to GROUND
// Connect a 10K resistor from pin 2 (data) to pin 1 (power) of the
sensor


// Initialize DHT sensor.
// Note that older versions of this library took an optional third
parameter to
// tweak the timings for faster processors.  This parameter is no
longer needed
// as the current DHT reading algorithm adjusts itself to work on
faster procs.
DHT dht(DHTPIN, DHTTYPE);


void setup() {
  Serial.begin(9600);
  Serial.println("DHT22 test!");


  dht.begin();
}


void loop() {
  // Wait a few seconds between measurements.
  delay(2000);


  // Reading temperature or humidity takes about 250 milliseconds!
  // Sensor readings may also be up to 2 seconds 'old' (its a very
slow sensor)
  float h = dht.readHumidity();
  // Read temperature as Celsius (the default)
  float t = dht.readTemperature();
```

```
  // Read temperature as Fahrenheit (isFahrenheit = true)
  float f = dht.readTemperature(true);


  // Check if any reads failed and exit early (to try again).
  if (isnan(h) || isnan(t) || isnan(f)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }


  // Compute heat index in Fahrenheit (the default)
  float hif = dht.computeHeatIndex(f, h);
  // Compute heat index in Celsius (isFahreheit = false)
  float hic = dht.computeHeatIndex(t, h, false);


  Serial.print("Humidity: ");
  Serial.print(h);
  Serial.print(" %\t");
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.print(" *C ");
  Serial.print(f);
  Serial.print(" *F\t");
  Serial.print("Heat index: ");
  Serial.print(hic);
  Serial.print(" *C ");
  Serial.print(hif);
  Serial.println(" *F");
}
```

(Sevold, 2017)

EPA Standard Values

According to the EPA, no standard values were found- however the standard values for humidity indoors according to their 'Building Air Quality Guide' are; temperature range above 40°F and below 100° with a relative humidity (rh) of at least 40%.

It also states that if a unit of air contains half of the water vapor it can hold, it is said to be at 50% relative humidity (RH). As the air cools, the relative humidity increases. If the air contains all of the water vapor it can hold, it is at 100% RH, and the water vapor condenses, changing from a gas to a liquid. It is possible to reach 100% RH without changing the amount of water vapor in the air (its "vapor pressure" or "absolute humidity"); all that is required is for the air temperature to drop to the "dew point." Relative humidity and temperature often vary within a room, while the absolute humidity in the room air can usually be assumed to be uniform. Therefore, if one side of the room is warm and the other side cool, the cool side of the room has a higher RH than the warm side. The highest RH in a room is always next to the coldest surface. This is referred as the "first condensing surface," as it will be the location where condensation first occurs, if the relative humidity at the surface reaches 100%.

Measurements

Fieldwork at University of Aruba;

The humidity was measured on 23/10/2017 at approximately 11:30 A.M in classroom A. As can be seen in the measurements below, there is a noticeable difference in the average measurements, evidently because the temperature and humidity in class and outside of the class are very different. This observation has been done taking in to account that the air-conditioning was on at 23 degrees in classroom A. Running an air-conditioning system can also help internal humidity levels drop, air from the device circulating throughout the chosen area, decreasing moisture present in it as the air is cooled and shifted drying it as such. In classroom A the average relative humidity was recorded at 63.30%, which indicates that it is at a satisfactory indoor air quality.

```
Humidity: 62.90 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.43 *C 75.97 *F /*/ average temp: 24.21 average humidity: 63.50
Humidity: 62.70 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.31 *C 75.76 *F /*/ average temp: 24.21 average humidity: 63.47
Humidity: 62.80 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.43 *C 75.97 *F /*/ average temp: 24.21 average humidity: 63.45
Humidity: 62.70 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.42 *C 75.96 *F /*/ average temp: 24.21 average humidity: 63.42
Humidity: 62.60 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.42 *C 75.96 *F /*/ average temp: 24.22 average humidity: 63.40
Humidity: 62.50 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.31 *C 75.75 *F /*/ average temp: 24.22 average humidity: 63.37
Humidity: 62.40 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.41 *C 75.95 *F /*/ average temp: 24.22 average humidity: 63.34
Humidity: 62.30 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.41 *C 75.94 *F /*/ average temp: 24.22 average humidity: 63.31
Humidity: 62.20 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.41 *C 75.94 *F /*/ average temp: 24.22 average humidity: 63.28
Humidity: 63.80 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.45 *C 76.01 *F /*/ average temp: 24.23 average humidity: 63.29
Humidity: 63.50 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.44 *C 76.00 *F /*/ average temp: 24.23 average humidity: 63.30
Humidity: 63.30 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.44 *C 75.99 *F /*/ average temp: 24.23 average humidity: 63.30
Humidity: 63.10 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.43 *C 75.98 *F /*/ average temp: 24.23 average humidity: 63.29
Humidity: 62.90 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.32 *C 75.77 *F /*/ average temp: 24.23 average humidity: 63.28
Humidity: 62.80 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.43 *C 75.97 *F /*/ average temp: 24.23 average humidity: 63.27
Humidity: 62.60 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.42 *C 75.96 *F /*/ average temp: 24.23 average humidity: 63.25
Humidity: 62.40 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.41 *C 75.95 *F /*/ average temp: 24.23 average humidity: 63.23
Humidity: 62.30 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.41 *C 75.94 *F /*/ average temp: 24.24 average humidity: 63.21
Humidity: 62.20 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.41 *C 75.94 *F /*/ average temp: 24.24 average humidity: 63.19
Humidity: 62.10 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.41 *C 75.93 *F /*/ average temp: 24.24 average humidity: 63.17
Humidity: 61.70 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.40 *C 75.91 *F /*/ average temp: 24.24 average humidity: 63.14
Humidity: 61.40 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.39 *C 75.90 *F /*/ average temp: 24.24 average humidity: 63.10
Humidity: 61.30 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.39 *C 75.90 *F /*/ average temp: 24.24 average humidity: 63.06
Humidity: 61.20 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.27 *C 75.69 *F /*/ average temp: 24.24 average humidity: 63.03
Humidity: 61.20 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.27 *C 75.69 *F /*/ average temp: 24.24 average humidity: 62.99
Humidity: 61.10 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.27 *C 75.69 *F /*/ average temp: 24.24 average humidity: 62.95
Humidity: 61.20 %      Temperature: 24.30 *C 75.74 *F  Heat index: 24.38 *C 75.89 *F /*/ average temp: 24.24 average humidity: 62.92
Humidity: 61.70 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.29 *C 75.72 *F /*/ average temp: 24.24 average humidity: 62.90
Humidity: 61.80 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.29 *C 75.72 *F /*/ average temp: 24.24 average humidity: 62.88
Humidity: 61.80 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.29 *C 75.72 *F /*/ average temp: 24.24 average humidity: 62.86
Humidity: 62.00 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.29 *C 75.73 *F /*/ average temp: 24.24 average humidity: 62.84
Humidity: 62.20 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.30 *C 75.74 *F /*/ average temp: 24.24 average humidity: 62.83
Humidity: 62.20 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.30 *C 75.74 *F /*/ average temp: 24.24 average humidity: 62.82
Humidity: 61.90 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.29 *C 75.73 *F /*/ average temp: 24.24 average humidity: 62.81
Humidity: 61.90 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.29 *C 75.73 *F /*/ average temp: 24.24 average humidity: 62.79
Humidity: 61.70 %      Temperature: 24.20 *C 75.56 *F  Heat index: 24.29 *C 75.72 *F /*/ average temp: 24.24 average humidity: 62.77
```

The second recording was done outside of the classroom under the gazebo. The sensor was on for approximately 5 minutes at 1:30 P.M. and the average temperature measured was 75.02% rh. Which is evidently higher than the previous recording. This higher humidity and high temperature indicates that the air quality outside was not satisfactory.

```
Humidity: 73.00 %       Temperature: 29.80 *C 85.64 *F  Heat index: 35.26 *C 95.48 *F /*/ average temp: 28.95 average humidity: 78.43
Humidity: 72.80 %       Temperature: 29.70 *C 85.46 *F  Heat index: 34.96 *C 94.93 *F /*/ average temp: 28.97 average humidity: 78.27
Humidity: 72.60 %       Temperature: 29.80 *C 85.64 *F  Heat index: 35.17 *C 95.30 *F /*/ average temp: 28.99 average humidity: 78.11
Humidity: 72.60 %       Temperature: 29.80 *C 85.64 *F  Heat index: 35.17 *C 95.30 *F /*/ average temp: 29.01 average humidity: 77.96
Humidity: 72.60 %       Temperature: 29.90 *C 85.82 *F  Heat index: 35.42 *C 95.76 *F /*/ average temp: 29.04 average humidity: 77.82
Humidity: 72.60 %       Temperature: 29.80 *C 85.64 *F  Heat index: 35.17 *C 95.30 *F /*/ average temp: 29.06 average humidity: 77.69
Humidity: 72.70 %       Temperature: 29.90 *C 85.82 *F  Heat index: 35.45 *C 95.81 *F /*/ average temp: 29.08 average humidity: 77.57
Humidity: 72.70 %       Temperature: 29.90 *C 85.82 *F  Heat index: 35.45 *C 95.81 *F /*/ average temp: 29.10 average humidity: 77.45
Humidity: 72.70 %       Temperature: 29.90 *C 85.82 *F  Heat index: 35.45 *C 95.81 *F /*/ average temp: 29.12 average humidity: 77.33
Humidity: 73.20 %       Temperature: 30.00 *C 86.00 *F  Heat index: 35.83 *C 96.50 *F /*/ average temp: 29.14 average humidity: 77.24
Humidity: 73.10 %       Temperature: 30.00 *C 86.00 *F  Heat index: 35.81 *C 96.45 *F /*/ average temp: 29.16 average humidity: 77.14
Humidity: 73.00 %       Temperature: 30.00 *C 86.00 *F  Heat index: 35.78 *C 96.41 *F /*/ average temp: 29.18 average humidity: 77.05
Humidity: 72.90 %       Temperature: 30.00 *C 86.00 *F  Heat index: 35.76 *C 96.36 *F /*/ average temp: 29.19 average humidity: 76.96
Humidity: 72.70 %       Temperature: 30.00 *C 86.00 *F  Heat index: 35.71 *C 96.27 *F /*/ average temp: 29.21 average humidity: 76.87
Humidity: 72.60 %       Temperature: 30.10 *C 86.18 *F  Heat index: 35.94 *C 96.69 *F /*/ average temp: 29.23 average humidity: 76.78
Humidity: 72.50 %       Temperature: 30.20 *C 86.36 *F  Heat index: 36.18 *C 97.12 *F /*/ average temp: 29.25 average humidity: 76.69
Humidity: 72.30 %       Temperature: 30.10 *C 86.18 *F  Heat index: 35.86 *C 96.55 *F /*/ average temp: 29.27 average humidity: 76.61
Humidity: 72.30 %       Temperature: 30.20 *C 86.36 *F  Heat index: 36.12 *C 97.02 *F /*/ average temp: 29.28 average humidity: 76.52
Humidity: 72.10 %       Temperature: 30.10 *C 86.18 *F  Heat index: 35.81 *C 96.46 *F /*/ average temp: 29.30 average humidity: 76.44
Humidity: 72.00 %       Temperature: 30.10 *C 86.18 *F  Heat index: 35.79 *C 96.42 *F /*/ average temp: 29.32 average humidity: 76.35
Humidity: 72.00 %       Temperature: 30.20 *C 86.36 *F  Heat index: 36.05 *C 96.88 *F /*/ average temp: 29.33 average humidity: 76.27
Humidity: 71.80 %       Temperature: 30.20 *C 86.36 *F  Heat index: 35.99 *C 96.79 *F /*/ average temp: 29.35 average humidity: 76.19
Humidity: 71.50 %       Temperature: 30.20 *C 86.36 *F  Heat index: 35.91 *C 96.65 *F /*/ average temp: 29.36 average humidity: 76.11
Humidity: 71.20 %       Temperature: 30.20 *C 86.36 *F  Heat index: 35.84 *C 96.51 *F /*/ average temp: 29.38 average humidity: 76.02
Humidity: 71.00 %       Temperature: 30.30 *C 86.54 *F  Heat index: 36.04 *C 96.87 *F /*/ average temp: 29.39 average humidity: 75.93
Humidity: 70.80 %       Temperature: 30.30 *C 86.54 *F  Heat index: 35.99 *C 96.78 *F /*/ average temp: 29.41 average humidity: 75.85
Humidity: 70.70 %       Temperature: 30.30 *C 86.54 *F  Heat index: 35.96 *C 96.73 *F /*/ average temp: 29.42 average humidity: 75.76
Humidity: 70.60 %       Temperature: 30.30 *C 86.54 *F  Heat index: 35.94 *C 96.69 *F /*/ average temp: 29.44 average humidity: 75.68
Humidity: 70.40 %       Temperature: 30.30 *C 86.54 *F  Heat index: 35.88 *C 96.59 *F /*/ average temp: 29.45 average humidity: 75.59
Humidity: 70.30 %       Temperature: 30.30 *C 86.54 *F  Heat index: 35.86 *C 96.54 *F /*/ average temp: 29.47 average humidity: 75.51
Humidity: 70.10 %       Temperature: 30.40 *C 86.72 *F  Heat index: 36.06 *C 96.91 *F /*/ average temp: 29.48 average humidity: 75.42
Humidity: 70.00 %       Temperature: 30.40 *C 86.72 *F  Heat index: 36.03 *C 96.86 *F /*/ average temp: 29.49 average humidity: 75.34
Humidity: 70.00 %       Temperature: 30.50 *C 86.90 *F  Heat index: 36.29 *C 97.32 *F /*/ average temp: 29.51 average humidity: 75.26
Humidity: 70.00 %       Temperature: 30.50 *C 86.90 *F  Heat index: 36.29 *C 97.32 *F /*/ average temp: 29.52 average humidity: 75.18
Humidity: 69.60 %       Temperature: 30.50 *C 86.90 *F  Heat index: 36.18 *C 97.12 *F /*/ average temp: 29.54 average humidity: 75.10
Humidity: 69.50 %       Temperature: 30.50 *C 86.90 *F  Heat index: 36.15 *C 97.07 *F /*/ average temp: 29.55 average humidity: 75.02
```

Air temperature is a key measurement alongside relative humidity. This is because the “relative” aspect is effectively “relative to temperature”. For a given air sample, a rise in temperature means a fall in relative humidity. For example, at a humidity of 50 % rh, a temperature rise from 20 °C to 21 °C will cause relative humidity to fall by about 3 % rh. (Bell, 2011)

Average findings Landfill dump site and in- and outside the UA

	Temperature	Heat Index	Humidity1 At the dump	Humiditity at UA inside
1	34.60 ˚C	30.52 ˚C	71.60%	62.90%
2	34.80 ˚C	49.89 ˚C	70.50%	62.70%
3	35.00 ˚C	49.80 ˚C	69.70%	62.80%
4	36.20 ˚C	50.76 ˚C	63.50%	62.70%
5	34.90 ˚C	49.19 ˚C	68.60%	62.60%
6	35.00 ˚C	49.38 ˚C	68.30%	62.50%
7	35.00 ˚C	48.99 ˚C	67.60%	62.40%
8	35.00 ˚C	48.71 ˚C	67.10%	62.30%
9	35.80 ˚C	48.60 ˚C	62.00%	62.20%
10	35.00 ˚C	48.28 ˚C	66.30%	63.80%
11	35.10 ˚C	48.78 ˚C	66.60%	61.70%
12	35.80 ˚C	48.60 ˚C	62.00%	61.40%
13	35.10 ˚C	47.70 ˚C	64.60%	62.30%
14	35.10 ˚C	47.38 ˚C	64.00%	62.20%
15	36.20 ˚C	50.15 ˚C	61.80%	61.20%
16	35.10 ˚C	47.44 ˚C	64.10%	61.70%
17	35.20 ˚C	47.66 ˚C	63.90%	63.50%
18	35.40 ˚C	48.10 ˚C	63.50%	63.25%
19	35.50 ˚C	48.05 ˚C	62.80%	61.70%
	Temperature		Hummidity (dump)	Hummidity (inside UA)
AVERAGE	35.00 ˚C		65.71%	62.41%

Average temperature	Hummidity At UA outside	average temperature outside
24.3˚C	73.00%	30˚C
24.3˚C	72.80%	30˚C
24.3˚C	72.60%	30˚C
24.3˚C	72.80%	30˚C
24.3˚C	72.40%	30˚C
24.3˚C	72.50%	30˚C
24.3˚C	72.30%	30˚C
24.3˚C	72%	30˚C
24.3˚C	71.80%	30˚C
24.3˚C	71.50%	30˚C
24.3˚C	71.20%	30˚C
24.3˚C	71.20%	30˚C
24.3˚C	71.50%	30˚C
24.3˚C	71.30%	30˚C
24.3˚C	71.10%	30˚C
24.3˚C	70%	30˚C
24.3˚C	70%	30˚C
24.3˚C	69.60%	30˚C
24.3˚C	69.50%	30˚C
Temperature	Hummidity. (outside UA)	Temperature
24.3˚C	71.53%	30˚C

Observation Landfill dump site

It had rained the day before Monday the 30th October 2017 , and there was also light rainfall early in the morning. Things turned bright before we left school, the sky was cloudy, but the sun was shining bright.

As we got to the landfill, the temperature was hot and sticky (humid). The temperature was of course humid, since it was cloudy. The smell at the site was overwhelming, as you could smell burning tires, burning waste and even the scent of burning carcasses.

It felt like all the particles were flying around in the air and were trying to stick to our bodies.

There were quite a few trucks arriving at the dump to dispose of their waste, outside it was hard to breathe without wanting to gag at the same time.

While waiting for the chance to go up the landfill we could see the clouds starting to form around the landfill area, but the sun was still shining.

We were experiencing some issues with the Arduino sensor, and we had to wait to go up last so that we could get another sensor.

As soon as we got out of the car when we reached the top of the landfill, it became harder to breathe, as we were more exposed to the burning waste. At one point it felt like all the burning particles in the air were being inhaled by our lungs.

Regardless of us being on top of a landfill, the view was breathtaking: you could see the ocean, the Barcadera harbor area, and you could see the Hooiberg and the beautiful landscape surrounding it.

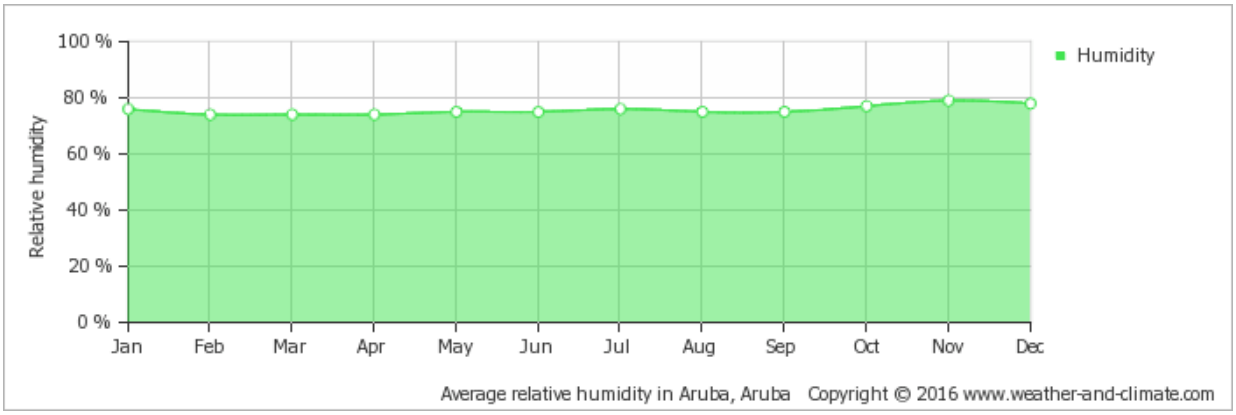
About 10 minutes after we got out of the car at the top of the landfill, it started to rain, making it difficult to gather data.

Noticeable was that during the drive up, you could see that they had designated areas for the different types of waste being disposed of: an area for carcasses, area for tires and similar waste, an area for household waste etc.

Comparing with yearly standards on Aruba

- The average humidity at the dump on 30/10/17 at 11:40h was 65,71% in Aruba
- The average humidity in class on 23/10/2017 at 11:30h was 62,41% in Aruba
- The average humidity outside class on 23/10/2017 at 11:50h was 71,53% in Aruba
- As mentioned before the average yearly humidity on Aruba was 77.4% for the period 1981 – 2010.

According to the weather station in Aruba measurements have shown that the month November is on average the most humid month and April is the least humid month. In this table below you can find the mean monthly relative humidity over the year in Aruba from 2016.



Giving this average humidity, measured on different places, we can conclude that when measuring the humidity in an outside environment, the number is higher compared to inside environment. We see that the amount of humidity at the dump is less than the humidity we measured outside the class. The three average measurements we took were all under the yearly average humidity of Aruba. When measuring the humidity, you must be critical considering that

October/ November is stated as the most humid month in the year although our measures, taken at the end of October, beginning of November are all under the average humidity level.

Humidity healthy levels

According to the Environmental Protection Agency (EPA) there are 3 fundamental factors to healthy air. In order for us to have a healthy air, the air needs to be clean, fresh and it must have a proper humidity. A proper and ideal indoor relative humidity for healthy and comfort is around 30 and 40 percent in the winter months, to below 50 percent during the summer. Conserving relative humidity below 50% prevents dust mite infestations, mold and mildew growth, and inhibits bacteria. Thus keeping the relative humidity healthy. Having a lower relative humidity also reduces the out-gassing of VOCs. In colder climates, wintertime humidity levels must be even lower, generally 30-40%, when the humidity is below 30-40 % it avoids condensation on windows and other surfaces. (Relative Humidity and Your Home, 2017) In general, this temperature guide will show you where to keep your indoor relative humidity levels to ensure comfort.

- Outdoor temperature over 50˚F, indoor humidity levels shouldn't exceed 50%
- Outdoor temperature over 20˚F, indoor humidity levels shouldn't exceed 40%
- Outdoor temperature between 10˚F and 20˚F, indoor humidity levels shouldn't exceed 35%
- Outdoor temperature between 0˚F and 10˚F, indoor humidity levels shouldn't exceed 30%

- Outdoor temperature between -10˚F and 0˚F, indoor humidity levels shouldn’t exceed 25%
- Outdoor temperature between -20˚F and -10˚F, indoor humidity levels shouldn’t exceed 20%
- Outdoor temperature at -20˚F or lower, indoor humidity levels shouldn’t exceed 15% (Frequently Asked HVAC Questions, 2017)

Negative Effects of Humidity on Your Health (Outdoors)

According to (Negative Effects of Humidity, 2017), the most immediate effect of high humidity is personal discomfort. When it’s too hot and humid, our bodies dissipate heat by varying the rate and depth of blood circulation, by losing water through the skin and sweat glands, and-as the last extremity is reached-by panting (breathing rapidly), when blood is heated above 98.6 degrees.

As the heart begins to pump more blood, the blood vessels dilate to accommodate the increased flow, and the bundles of tiny capillaries threading through the upper layers of skin are put into operation. The excess heat drains off into the cooler atmosphere and at the same time, water diffuses through the skin as perspiration (sweat). The skin handles about 90 percent of the body's heat dissipating function.

Although sweating is one of the primary mechanisms that the body uses to cool off, at times, the humidity in the air can get in its way. The more humid the air is, the more water molecules it contains, and the less the air will "want" to evaporate sweat. Under conditions of high temperature (above 90 degrees) and high relative humidity, the body will do everything it can to maintain its internal temperature at 98.6 degrees. (Jakuboski, 2013)

According to (Jakuboski, 2013), if the relative humidity is 100%, which means that the outside air is already saturated with water molecules, sweat evaporation will not take place, because the humidity level will obstruct evaporation and the body will not be able to rid itself of its excess heat. When this occurs, sweat won't evaporate, the body's thermoregulation mechanism is defeated and the body temperature will begin to rise. Perspiration, in itself, does nothing to cool the body, it is the water that is removed by evaporation which gives the sensation of a 'cooling effect' on the body.

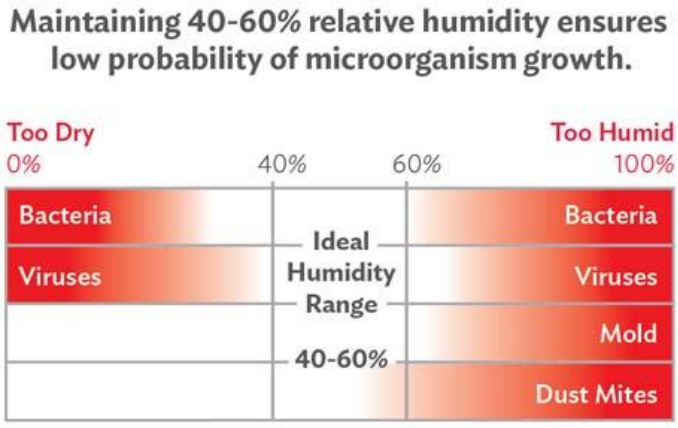
Heat disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating, or a chemical (salt) imbalance caused by too much sweating. When heat gain exceeds the level the body can remove, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and heat-related illness may develop (i.e. heat rash, heat cramps, exhaustion, heat stroke, dehydration) Obviously there are thresholds for both temperature and humidity above which we see an increase in death, and it's to be a different temperature and relative humidity level depending on the region. Thanks to technological improvements and the development of air conditioners, the number-one factor that ameliorates death from heat in our society today is access to air conditioning.

Some key ways to avoid overheating while outdoors are first, to be aware of not only the temperature, but the heat index; to drink plenty of water; and to take it easy, slow down, and cool off when noticing any sign of fatigue, headache, or increased pulse.

Negative Effects of High Humidity on Your Health (Indoors)

Mold, Mildew and other Microscopic Organisms

A humid environment is a breeding ground for all sorts of microscopic organisms that can harm your health. Mildew and mold spores thrive in it, and they can be highly toxic once they get into your body. If mold is clearly visible inside your home, you have a problem that needs immediate attention. Even if there are no signs, mold and mildew can still spread throughout the vents, or



behind walls. (Web, 2017)

Dust mites also love humidity, and they're one of the biggest enemies for people who suffer from asthma and allergies. Needless to say, all sorts of bacteria can be found in spaces with high relative humidity. People who live in homes that are struck by mold growth and mildew get sick more often, and their overall health is a lot poorer. Asthma sufferers also experiences more frequent attacks. By getting a dehumidifier, it is possible to solve these problems (or at the very least alleviate them). (Web, 2017)

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Ledger

Pictured below is the DHT22 sensor and the Arduino Uno Board which was used to measure the Humidity at the University of Aruba.