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Approximation of the Dew Point Temperature Using a Cost Effective Weather Monitoring System

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Authors' contributions

This work was carried out in collaboration between all authors. Author EUK designed the study and wrote the first draft of the manuscript. Author OAS managed the analyses and also edited the initial draft of the study. Authors CAI and EE worked on the measurement of data and the statistical analysis. All authors read and approved the manuscript.

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ABSTRACT

In this era of global warming, research in weather measurement and prognostications are becoming more and more pertinent; getting the latest weather information and taking the necessary precautions have become a major issue all over the world. Dew point temperature is an important weather parameter that is used in estimating rain, snow, dew, evapotranspiration, near-surface humidity, other meteorological parameters and applications. This research is aimed at approximating the dew point temperature (using a self designed cost effective weather monitoring system) from the measured temperature and relative humidity. The results from this research show that the temperature and relative humidity have a significant influence on the dew point temperature and it was in good conformity with data obtained from other sources. Thus, this study would help in mitigating climate-induced environmental disasters and also improve agricultural productivity.

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1. INTRODUCTION

The study of weather is as old as the creation itself; it has always had a significant influence on the lives of people and shaped their cultures, beliefs, habits, attitudes, behaviour and their environments in general. Man has always tried to find out the causes of different weather conditions he finds himself in and possibly monitor and prognosticate what the weather would be at any given time. Taking weather and trying to forecast it appropriately can make a difference for the survival and prosperity of the human race [1].

Weather is mostly influenced by the following factors:

i) Location latitude
ii) Elevation
iii) Proximity to water bodies

The recent environmental dynamic as a result of climate changes is becoming an issue of great concern. Weather monitoring is of great significance and has uses in several areas ranging from keeping track of agricultural field weather conditions to industrial weather conditions monitoring. Weather measuring and monitoring would also assist in keeping track of various atmospheric climatic parameters, behaviors and information. In fact, there cannot be a study of the weather neither its prognostication without the knowledge of the prevailing conditions of the atmosphere [1,2].

Man has always implored and devised means of measuring different elements of the weather; with the advancement in science and technology, new methods and equipment have been developed to measure, collect and monitor weather information and today a whole field of this study is devoted to meteorology, which is the science of the atmosphere. Its domain is the atmosphere of the whole universe and its practice involves the daily cooperation of every action on the universe. In meteorology, the data measured and collected are used in monitoring and prognosticating the weather**,** which are useful in one way or the other way in the course of our daily activities [1,3].

Meteorologically, weather is used to describe the momentary atmospheric conditions at a certain place. It is the state of the atmosphere of a given place at a particular time. Weather describes the condition of the atmosphere over a short period of time [4].

The climate of an area, which describes the average weather conditions, is known through the average weather over a long period of time.In describing the atmospheric conditions of a given place at a given time, certain weather elements or parameters must be known, measured and quantified. Some of the most crucial weather elements are temperature, relative humidity, atmospheric pressure, wind speed and direction, precipitation, solar and light intensity. Temperature is a widely measured variable and is a very critical factor in determining the weather; because it influences and controls other elements of the weather [2].

2. DEW POINT TEMPERATURE

The dew point temperature is the temperature at which the moisture/liquid water (water vapor) in the air begins to condense or evaporates at same rate at which it condenses. Dew point is of great interest to meteorologists because it is a fundamental measure of the state of the atmosphere in terms of how much water vapor is presented [5].

Furthermore, dew point temperature can provide a fairly direct sense of how comfortable or uncomfortable warm air will feel. Dew point can also give us a reasonable starting point for estimating low temperatures the following day, as under certain conditions the lowest temperature will end up pretty close to the dew point at the time of maximum temperature the day before. We can also use projections of dew point temperature to aid in prognosticating the formation of fog or dew and in the estimating rain, snow, dew, evapotranspiration, near-surface humidity and other meteorological parameters. Also, higher dew points through the lower atmosphere (especially those above 60^{o}) can help to support more numerous and/or intense thunderstorms when other factors favor their formation. The dew point is directly related to the amount of water vapour; it is directly proportional to water vapour [6].

2.1 Significance of Dew Point Temperature

Apart from some of the usefulness of dew point temperature alighted above, its significance touches each of us when one realizes that this

important factor, the amount of moisture in a gas, impacts much more than Heating, Ventilation and Cooling (HVAC) considerations.

(i) It is a vital factor in convective heat transfer, combustion of fossil fuels and combustion engineering, drying of paper, cardboard, plastics, wood, tobacco, leather, printed goods, textiles and grain.
(ii) It plays a major role in the efficient use of energy in many chemical manufacturing processes as well as the attainment of high product yield.
(iii) The effect of moisture in gases also plays a very significant role in corrosion phenomena which can result in damage and loss of not only unprotected metals, like iron and steel structural components, but also improperly treated or stored steel and other metal products [6].

3. MATERIALS AND METHODS

Several components and devices, which are called embedded system when they assembled [7], were used for the design of the weather monitoring system that was used for the measurement. These components and devices were properly selected to meet the Directive 2002/95/EC of the European Parliament and of the Council on the Restriction on the use of certain hazardous substances in Electrical and Electronic Equipment, the Institute of Electrical and Electronic Engineering (IEEE) and other regulatory bodies on instrumentation standards for obtaining valid and accurate measurements.

The devices and components used for the design of this works are:

(i) Arduino Mega 2560 Microcontroller.
(ii) Some Modern Reliable Sensor (DHT11 digital temperature and humidity sensor, BMP 180 Pressure and Temperature Sensor and TSL 2561 Light Intensity Sensor).
(iii) Data Logger which consist of the Real Timer (DS 1307), Memory Card
(iv) HD444780 LCD.
(v) Other Materials/Circuit Elements like Connectors, Resistors (1000Ω Pot Resistor and Fixed 470Ω Resistor), Power source.

3.1 Block Diagram of the Designed Weather Monitoring System

The block diagram of the designed system is shown in Fig. 1 and also the snapshot of the designed weather monitoring system is showed in Fig. 2. The diagram consists of the Microcontroller (Arduino Mega 2560 Microcontroller) which is the heart of the system, Sensors (DHT11 digital temperature and humidity sensor, TSL 2561 Light Intensity Sensor and BMP 180 Pressure and Temperature Sensor), Data Logger which consist of the Real Timer (DF 1307), Memory Card, LCD Display (HD 444780 LCD) and other materials and circuit elements like Connectors, Resistors (1000Ω Pot Resistor and Fixed 470Ω Resistor).

When the design and implementation process were completed, all the components and devices have been mounted and embedded. Hardware testing was carried out. It was found that all the circuits were working properly and there were no loose connection between the components.

4. DISCUSSION OF RESULTS

The weather monitoring system is designed in such a way that it can be used remotely and the readings are displayed on the user friendly LCD display in numerical digital values and can also be sent to computer via the programmed micro SD card or through the serial port (The Arduino SD Card Module).

Weather measurements of temperature and relative humidity were carried out in Benin City, Edo State Nigeria (Latitude: 6°20′17″ N, Longitude: 5°37′32″ E and Elevation above sea level: 87.88 m ≈ 288 ft) during the month of March, 2017 using the designed weather monitoring system and the results were analyzed and compared with weather data obtained from other sources (the Nigerian Meteorological Agency; NMA and online weather reports). The measurement results are tabulated in Table 1 and Table 2 for the temperature and relative humidity respectively.

Thereafter, the approximation of the dew point temperature using the Thumb rule (Eqn. 1) and (Eqn. 2) was carried out.

$$Td = T - \left(\frac{100 - RH}{5}\right) \quad (1)$$

Also we can use a complex formula;

$$Td = Tn\frac{\ln\left(\frac{RH}{100}\right) + \left(\frac{mT}{Tn} + T\right)}{m - \ln\left(\frac{RH}{100}\right) - \left(\frac{mT}{Tn} + T\right)} \quad (2)$$

Where *Td* is the dew point, *T* is the temperature, *RH* is the relative humidity, while, for the temperature range –40℃ to 0℃, *Tn* = 272.62℃ and *m* = 22.46, and for the temperature range 0℃ to 50℃, *Tn* = 243.12℃ and *m* = 17.62.

The dew point values were calculated after receiving the air temperature and relative humidity values from the weather monitoring system. The dew point value can be calculated automatically from the computer using MATLAB after receiving the temperature and relative humidity values [4]. Table 3 contains the approximated dew point temperature from the measured temperature and relative humidity accordingly.

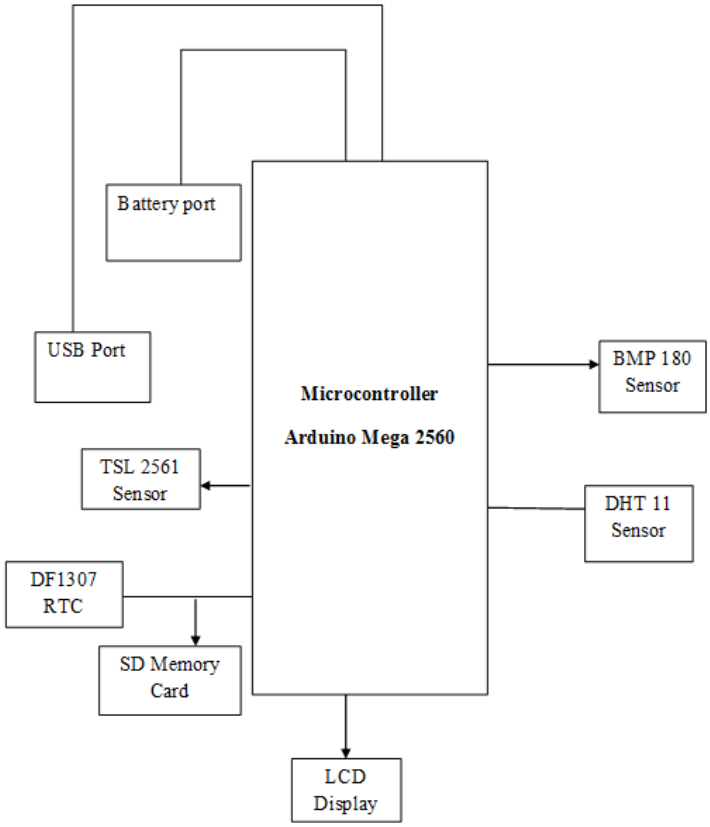

Fig. 1. Block diagram of the designed weather monitoring system

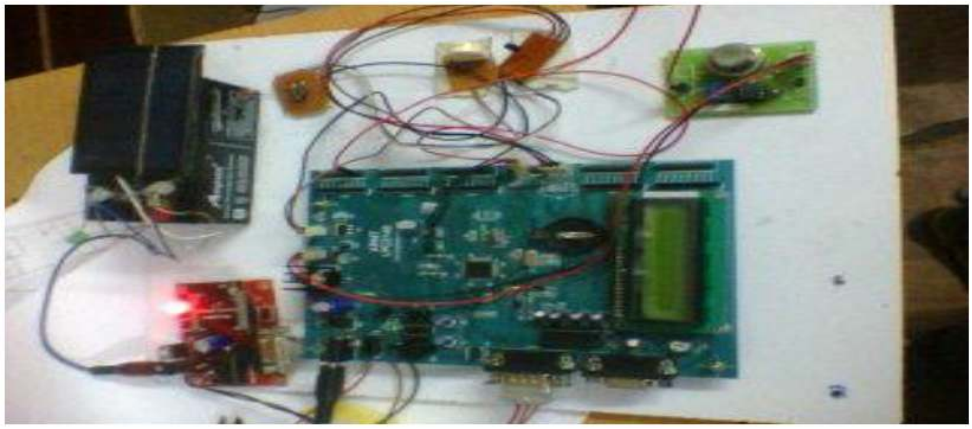

Fig. 2. Snapshot of the designed weather monitoring system

Table 1. Temperature

Date/Time	Measured average temperature (^{o}C)	Source average temperature (^{o}C)	
		Source A	Source B
01/03/2017	29	28	28
02/02/2017	28	28	27
03/02/2017	30	29	28
04/02/2017	30	30	31
05/02/2017	27	26	27
06/02/2017	28	29	28
07/02/2017	31	30	31
08/02/2017	32	33	32
Mean Total	**29.38**	**29.13**	**29.00**

Table 2. Relative humidity

Date/Time	Measured average humidity (%)	Source average humidity (%)	
		Source A	Source B
01/03/2017	70	71	72
02/02/2017	79	80	80
03/02/2017	87	87	86
04/02/2017	91	87	90
05/02/2017	99	99	98
06/02/2017	93	94	92
07/02/2017	83	83	85
08/02/2017	58	59	60
Mean Total	**82.50**	**82.50**	**82.86**

Table 3. Dew point temperature

Date/ Time	Approximated average dew point (^{o}C)	Source average dew point (^{o}C)	
		Source A	Source B
01/03/2017	23.00	22	23
02/02/2017	23.80	24	23
03/02/2017	27.40	27	26
04/02/2017	28.20	28	29
05/02/2017	26.80	27	28
06/02/2017	26.60	27	26
07/02/2017	27.60	26	26
08/02/2017	23.60	24	25
Mean Total	**25.88**	**25.63**	**25.75**

Using some statistical analytic tools, it was observed that the temperature and relative humidity have a significant influence on the dew point temperature and it was in good conformity with those data obtained from other sources (NMA and online weather reports).

5. CONCLUSION

Weather is dynamic and it changes constantly. The change in one meteorological parameter (especially temperature) leads to change in almost all the other elements. Hence, by constant measuring, monitoring and prognosticating of these parameters would create certainly the tendencies of their acceleration. There is no doubt that an accurate measurement and proper observation and monitoring of the atmospheric conditions using proper meteorological instruments would be of great significant [8,9].

Weather has always been a major force of nature that has influenced mankind in a very authoritative approach for an elongated period of time. Its measurement and monitoring would make weather related data available for different purposes that could be essential for considering the geographical location, climate changes issues, agriculture based economy, for weather prognostications and their applications [10].

This research demonstrates the approximation of the dew point temperature using a self designed cost effective weather monitoring system from the measured temperature and relative humidity in the month of March, 2017. The results show that the temperature and relative humidity have a significant influence on the dew point temperature and it was in good conformity with those data obtained from other sources (NMA and online weather reports). Hence, this study would help to guide against the occurrences of climate induced environmental disasters and also improve agricultural productivity in our communities; this point makes this research an ideal choice.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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