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ARTICLE

Digital Portable Weather Station Monitoring System Using Arduino Uno

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ABSTRACT

The temperature, humidity, atmospheric pressure and altitude are the most important parameters of the environment. If those parameters are known, it will help to select the best crops for specific location which increases the productivity in agricultural field. This is very useful for countries like Nepal where the most of people in this country depends on agriculture. In this research, an Arduino based device is constructed which measures those parameters and record the data in real time. The DHT22 and BMP180 sensors are used for measuring those parameters whereas RTC and SD Card module is used to record the data in real time. Data can be displayed on LCD and serial monitor of computer or laptop. The data were collected at Tri-Chandra Multiple College, Ghantaghar and at Gaurighat, Chabahil with the help of Arduino based device.

In this project, the digital portable weather station monitoring system has been designed and data from this device compared with the data obtained from HTC-2 standard device and error analysis has been done.

1. Introduction

Observation of weather plays a vital role in our daily life. A proper study of weather can give us an idea about climate change and the advantage to predict the future behavior of weather. Knowledge of the environment can also be useful in the field of agriculture. Nepal is an agriculture dominated country, and the main economy of our country depends on agriculture. So, by studying the temperature, humidity, and altitude of a certain location, we can choose the best crop for that location, hence increase the productivity of the crops. Firstly, the thermometer is used as a temperature measuring device developed by Galileo Galilei in the 17th century. A German physicist D.G. Fahrenheit as well as contributed significantly to the development of thermometry proposed his own scale Fahrenheit. Similarly, Lord Kelvin introduces a new scale known as Kelvin scale, which of course is the standard unit of temperature used in Physics [1].

Experimental evidence shows that water vapor can be modeled as an ideal gas in the temperature range of -40˚C to +65˚C. The relative humidity is the ratio of the actual water vapor pressure to the saturated water vapor pressure at the same dry-bulb temperature [2]. Water vapor is a key agent in weather and climate. So, air humidity affects our security, our living conditions, our quality of life, and the efficiency of industrial production. The first device for air humidity measurement was built by Leonardo da Vinci, in the fifteenth century [3]. Atmospheric pressure case due to the weight of air present in the atmosphere. The device

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that measures atmospheric pressure is called barometer. The first barometer was invented by an Italian physicist and mathematician Evangelista Torricelli [4].

With the evaluation of time and development in science and technology, nowadays different types of devices or sensors are available for the measurement of environmental parameters. A work has been done with IoT based system by using Raspberry pi. DHT 11 sensor also has been used to measure temperature and humidity. The data are stored in Raspberry Pi and displayed on screen and other devices. The python code has been used to operate with Raspberry Pi. However Raspberry pi is very expensive as compared to the Arduino board. Arduino is cheap and easy to use for students or researchers [5].

1.1 Objectives

Following are the main objectives of this research:

•To construct a device, which measures and displays the values of variables (i.e. temperature, pressure, humidity and altitude) of environment as well as stored the data in real time.

•To study the environment of some specific location.

•To relate the variables & plotting graph between them.

•To compare the efficiency of this device with another classical device.

•To predict the probability of human civilization for some specific location.

1.2 Significance

•This device is helpful because it gives us information about our surrounding environmental variables.

•By using the information about temperature, humidity & altitude we can select the best crops for corresponding environment which can increase the productivity of agriculture field.

•By measuring the pressure of atmosphere, we can predict the future direction of flow of the wind.

•This is a digital device so data will be more accurate as compare to classical instrument.

•This device can store data automatically in real time.

1.3 Limitation

•All values of the parameters can't be measured because its sensors work in a limited range, so beyond the range of the sensors, the device is unable to work.

•The value of altitude is dependent on pressure, so the value of altitude can't be accurate in all situations.

2. Literature Review

In this field, a tremendous amount of work has been already done up to this date. In some of the system ESP8266 Wi-Fi module is also used which is able to send the data directly through the internet by using Wi-Fi which immediately plots the graph of given data in real time. Such device able to upload data to the cloud. These systems used the Thing Speak platform at which data can be observed from anywhere in the world through Internet. [6].

The manual Display and automatic real time data display device also designed by using an ESP8266 Wi-Fi module with DHT11 and Also, the data have been displayed using LCD [7].

In some devices, ZigBee is also used for the long range wireless data transmitter and receiver system without internet to measure the humidity, pressure, rain, dust in the air, and speed of the wind [8]. IoT-based device is also designed to measure the temperature and humidity. The data are transmitted through Wi-Fi with the help of the ESP8266 Wi-Fi module [9]. Simillarly, the similar type of device also designed by using the Atmega328P microcontroller and The data are monitored by using a 16*2 LCD[10]. In some case the DHT 11 sensor is used with the SD card to record the data in real time with the help of RTC module [11].

3. Methodology

3.1 Hardware used in Digital Portable Weather Station Monitoring System

In this research, DHT22 and BMP180 sensors have been using to measure temperature, humidity, pressure, and altitude. The measured values from sensors have been received by Arduino Uno. The Arduino displays those values in the LCD and as well on the serial monitor of the computer. These data also have been stored in an SD card with a real time. To indicate the time, the RTC module has used.

To construct this device the following Hardware components are used.

1.Arduino Uno
2.RTC-DS1307 Module
3.DHT-22
4.BMP180
5.SD card Module
6.LCD 20*4
7.Potentiometer
8.Jumper Wires
9.Bread Board
10.Resistors

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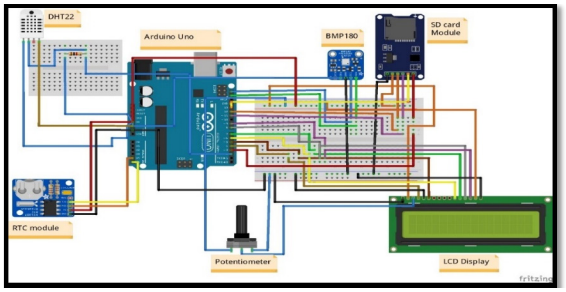

Figure 1. Circuit Diagram

3.2 Working

The circuit diagram of this Arduino based device is shown in above Figure 1. The DHT22 sensor is connected to Arduino to measure the value of temperature and humidity. The positive terminal of DHT22 is connected with +5Vpin Arduino and the negative terminal is connected with the GND pin of Arduino. The DATA pin of DHT22 is connected with Arduino's digital pin number 2. The BMP180 sensor is used to measure the value of barometric pressure. The positive pin of BMP180 is connected with the +3V pin of Arduino and the negative pin is connected with the GND pin Arduino. The SCL and SDA pin of BMP180 are connected to the SCL and SDA pin of Arduino respectively. The SD card module is used to connect the SD card to the Arduino. MISO, MOSI, SCK, CS pins of the SD card module are connected with Arduino's digital pin numbers 12, 11, 13, and 3 respectively. VCC and GND pins of SD card module are connected with +5V and GND pin of Arduino respectively.

The RTC module is used to record time. The SDA and SCL pins of the RTC module are connected with Arduino's analog pins A4 and A5 respectively. With the help of the SD card module and RTC module this device stores data in the SD card at a certain time interval with the indication time and date of recorded data. The VCC and GND pins of the RTC module are connected with +5V and GND pins of Arduino respectively. A 20*4 LCD display is used to monitor the data. The VSS and VDD pins of LCD are connected with +5V and GND pins of Arduino. The V0 pin of the LCD is connected with a 10k potentiometer which is used to adjust the contrast of the LCD. Further, the other two points of the potentiometer are connected to +5V and GND pin of Arduino to supply the power on it. The R/W pin of LCD is connected to the GND pin of Arduino. The LDC's pins RS, E, D4, D5, D6, and D7 are connected to digital pins of Arduino's 4, 5, 6, 7, 8, and 9 respectively. The pins A and K are connected to +5V and GND pins of Arduino respectively. Those circuits are designed in Fritzing software of version 0.9.3.

The final outlook of device is shown in figure 2 and 3 respectively.

Figure 2. Front View

Figure 3. Top View

4. Results

With the help of this device,data have been recorded in two different locations of Kathmandu valley.

4.1 Results Obtained at Tri-Chandra Multiple College, Ghantaghar

Figure 4. Tri-Chandra Multiple College, Ghantaghar

(Position: N27˚42.807'E085˚21.007' Latitude: N27˚42.458', Longitude: E085˚18.943', Altitude: 4208ft)

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4.2 Data Obtained from HTC-2 Standard Device

In this location, the data are recorded in the morning and afternoon. The following variation of temperature and humidity are obtained in those different phase of time.

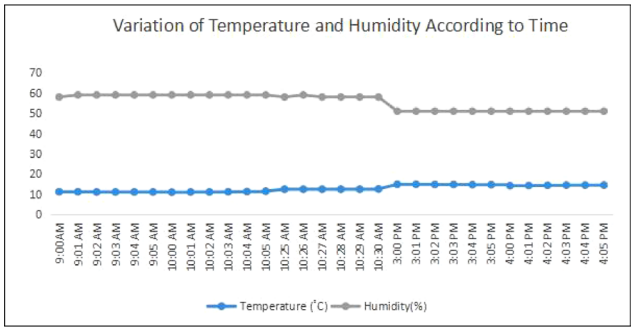

Figure 5. Variation of Temperature and Humidity with respect to Time obtained by using HTC-2 at Tri- Chandra Multiple College, Ghantaghar

Also, the variation in humidity according to temperature is obtained as below.

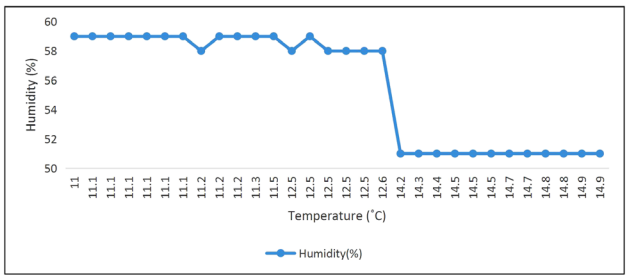

Figure 6. Variation in Humidity and Temperature Obtained by using HTC-2 at Tri-Chandra Multiple College, Ghantaghar

4.3 Data Obtained from Arduino Based Device

With the help of Arduino based device same analysis has been also done in the same location the results are as below.

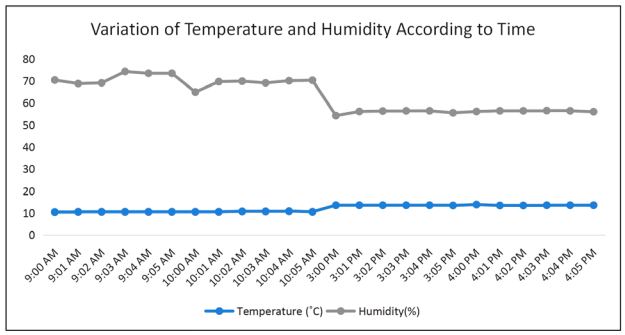

Figure 7. Variation of Temperature and Humidity with respect to Time obtained by using Arduino based device at Tri-Chandra Multiple College, Ghantaghar

Similarly, the relationship between variation of temperature and humidity using Arduino based device is obtained as below.

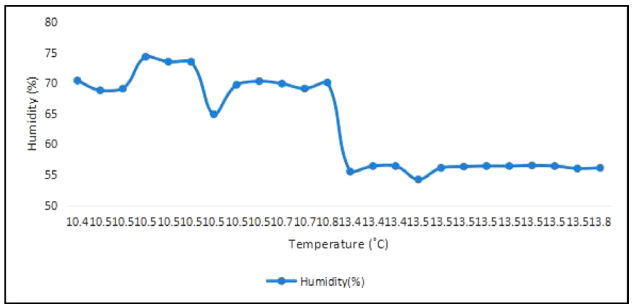

Figure 8. Variation of Humidity and Temperature obtained by using Arduino based device at Tri-Chandra Multiple College, Ghantaghar

4.4 Results Obtained at Gaurighat, Chabahil

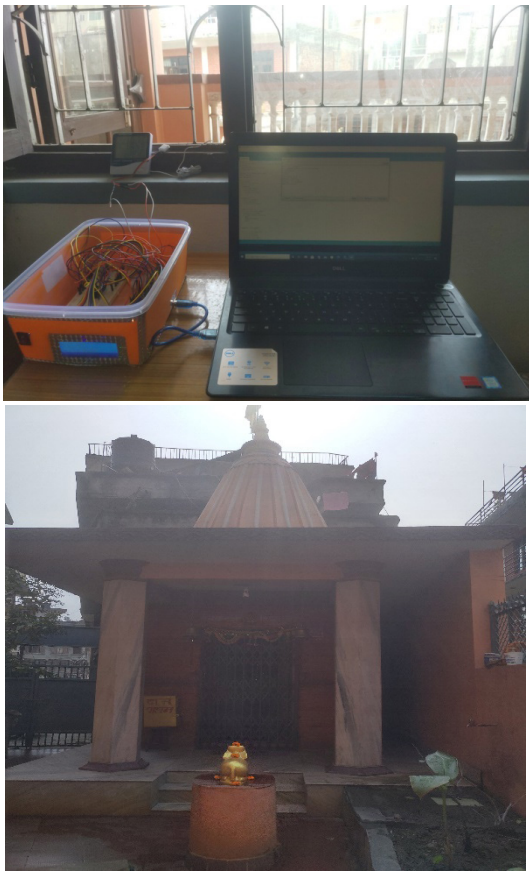

Figure 9. Gaurighat, Chabahil

(Position: N27˚42.846' E085˚21.049', Latitude: N27˚42.846', Longitude: E085˚21.049', Altitude: 4139ft)

4.5 Data Obtained from HTC-2 Standard Device

The measurement of temperature and humidity form 6AM – 4PM has been performed using HTC-2 standard device and the results have been obtained as below.

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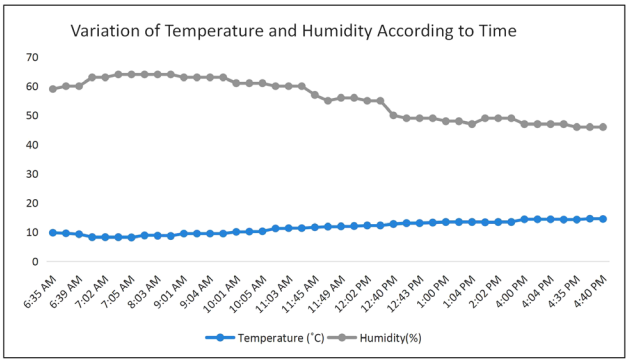

Figure 10. Variation of Temperature and Humidity with respect to Time obtained by using HTC-2 at Gaurighat, Chabahil

Also, the variation of humidity with respect to temperature at this location has obtained as below.

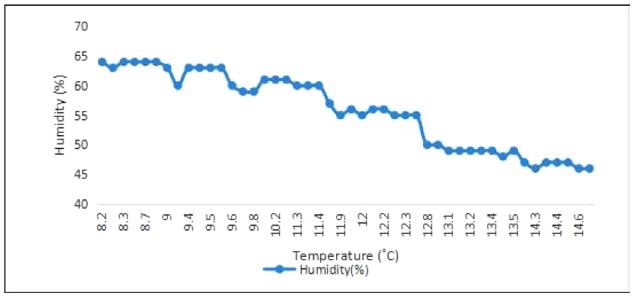

Figure 11. Variation of Humidity and Temperature obtain by using HTC-2 at Gaurighat, Chabahil

4.6 Data Obtained from Arduino Based Device

The measurement of different parameters has been performed at this location with the help of our device. The variation of temperature and humidity according to different phases of time has been obtained as below.

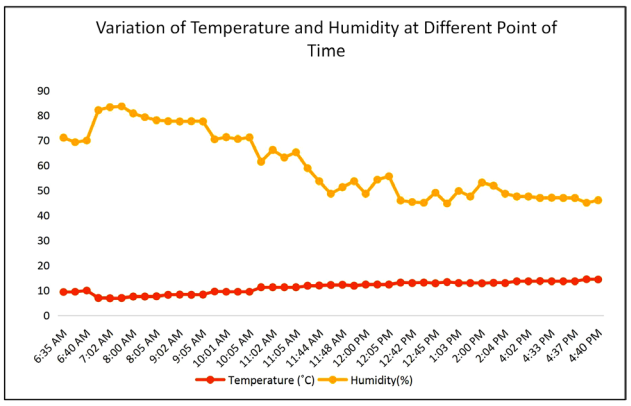

Figure 12. Variation of Temperature and Humidity with respect to Time obtain by using Arduino based device at Gaurighat, Chabahil

Also, the variation of humidity with change in time has obtained as below.

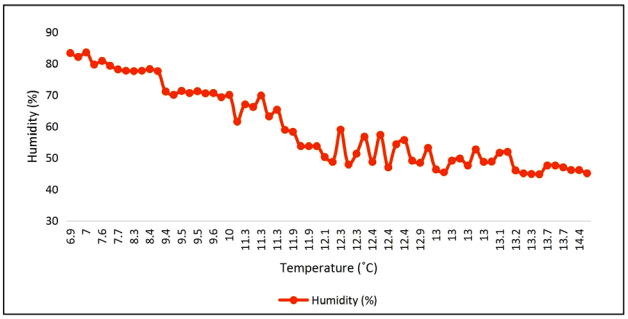

Figure 13. Variation of Humidity and Temperature obtained by using Arduino based device at Gaurighat, Chabahil

Using this device, the values of atmospheric pressure have been also measured at different time. The variation of atmospheric pressure according to time has obtained as below.

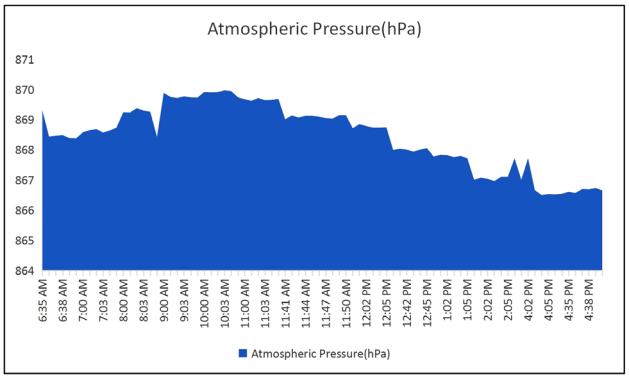

Figure 14. Variation of Atmospheric Pressure with respect to Time obtained by using Arduino based device at Gaurighat, Chabahil

The vibration of atmospheric pressure with change in altitude from sea level can also be obtained using this device.

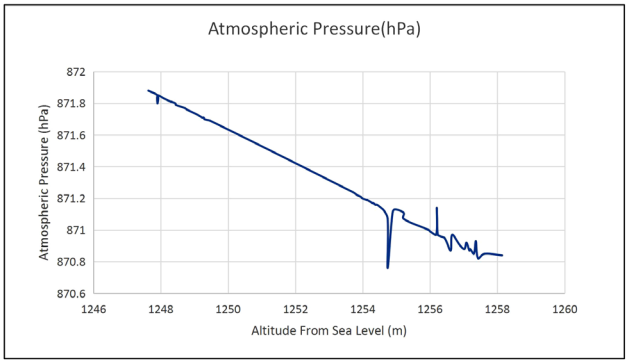

Figure 15. Variation of Atmospheric Pressure with respect to Altitude from sea level obtained by using Arduino based device at Gaurighat, Chabahil

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4.7 Comparison and Analysis of Data

The data obtained with the help of two devices have compared using linear and polynomial fitting results are as below.

4.8 Data Obtained from HTC-2 Standard Device

The linear and polynomial fitting on the variation of humidity according to change in temperature is as below.

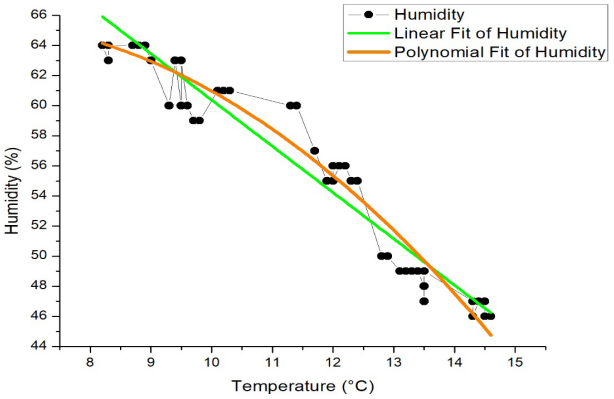

Figure 16. Polynomial and Linear fitting of data obtained by using HTC-2 Standard Device

The standard errors of linear and polynomial fitting are as following:

Table 1. Linear Fitting of data obtained by using HTC-2 Standard Device

S.N.				
1	Equation	y = a + b*x		
2	Adj. R-Square	0.93218		
3			Value	Standard Error
4	Humidity	Intercept	91.13605	1.10569
5	Humidity	Slope	-3.07573	0.0933

Table 2. Polynomial fitting of data obtained by using HTC-2 standard device

S.N.				
1	Model	Polynomial		
2	Adj. R-Square	0.95103		
3			Value	Standard Error
4	Humidity	Intercept	55.91829	6.39278
5	Humidity	B1	3.26602	1.14142
6	Humidity	B2	-0.27608	0.04957

4.9 Data Obtained from Arduino Based Device

The linear and polynomial fitting of variation of humidity according to change in temperature observed by Arduino based device has been seen as below.

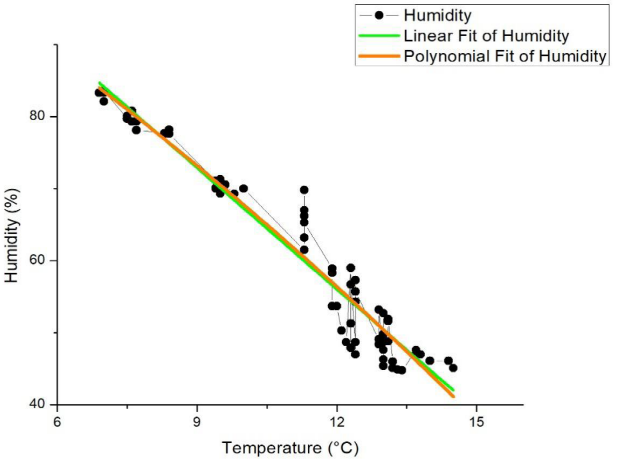

Figure 17. Polynomial and Linear fitting of data obtained by Arduino based device

The standard errors of linear and polynomial fitting of data obtain by using our devices have been seen as below.

Table 3. Linear fitting on data obtained by using Arduino based device

S.N.				
1	Equation	y = a + b*x		
2	Adj. R-Square	0.95187		
3			Value	Standard Error
4	Humidity	Intercept	123.45269	1.59151
5	Humidity	Slope	-5.61681	0.13859

Table 4. Polynomial fitting on data obtained by using our device

S.N.				
1	Model	Polynomial		
2	Adj. R-Square	0.95206		
3			Value	Standard Error
4	Humidity	Intercept	113.8637	8.49153
5	Humidity	B1	-3.71041	1.66418
6	Humidity	B2	-0.0899	0.07821

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4.10 Analysis of Measurement of Pressure and Altitude

Arduino based device is also capable of measurement of atmospheric pressure and altitude from sea level. The linear fitting of relation between pressure and altitude has obtained as below.

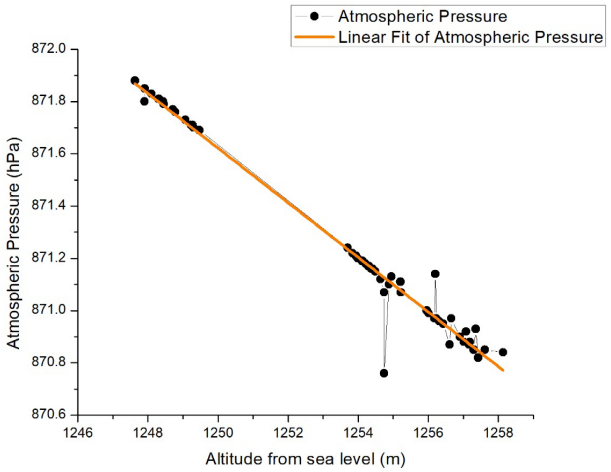

Figure 18. Graph of variation of Atmospheric pressure with change in Altitude from sea level

The standard error in measurement of variation of atmospheric pressure with change in altitude is as below.

Table 5. Linear fitting on variation of atmospheric pressure with change in Altitude from sea level

S.N.				
1	Equation	y = a + b*x		
2	Adj. R-Square	0.9728		
3			Value	Standard Error
4	Atmospheric Pressure	Intercept	1002.13104	2.95019
5	Atmospheric Pressure	Slope	-0.10441	0.00235

5. Conclusions

The digital portable weather station monitoring system has been constructed using Arduino Uno and compare its data with the standard device HTC-2.This device works with two major sensors and measures four parameters temperature, humidity, pressure and altitude from sea level. To find the accuracy and validity of values measured by this device, the data are recorded in two different locations of Kathmandu valley at Tri-Chandra Multiple College, Ghantaghar and Gaurighat, Chabahil.

The data obtained from this device has been fitted with linear line and polynomial curve using Origin Software. The standard error of intercept in linear fitting in the relation between humidity and temperature using HTC-2 standard device and Arduino based device have obtained as 1.10569 and 1.59151 respectively. Similarly, The polynomial fitting in the relation between humidity and temperature, the standard error in intercept using HTC-2 obtained as 6.39278 and 8.49153 respectively. From this project,we found that Arduino based device is also capable of measuring pressure and altitude. The different values of atmospheric pressure at different locations have been recorded and error analysis has been done. The linear fitting of those data shows a 2.95019 error in the intercept. We found Arduino based device is nearly equally accurate in the measurement of temperature and humidity as compared to HTC-2 standard device. The measurement of temperature and humidity that has done by Arduino based device is satisfactory as compare to HTC-2 standard device. Also, the measurement of atmospheric pressure and altitude is acceptable with 2.95019 standard error in intercept, on linear fitting. Also, outcome of this research is as per the expectations of the study in comparison with outcomes obtained by Rajesh Shrestha (2019) [10] and Paul Kamweru & Owino Ochieng Robinson (2020) [11], and following this study, the main goals had successfully reached.

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