Air Pollution Monitoring System Using Unmanned Aerial Vehicle in Bangladesh

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A thesis submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of
B.Sc. in Electrical & Electronic Engineering

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Abstract

Over the last few decades, the main minacious and dodgy calamity that grab the world's attention is "Greenhouse Effect". It is evident that Carbon dioxide, methane, nitrous oxide, fluorinated gasses and water vapor are the common phenomenon causing this disaster. These gasses remain in the atmosphere causing the temperature to rise as the sunlight can pass through the ozone layer, but they can't go back and trap inside the earth atmosphere. Being great concern to the future world, this proposal emphasizes on collecting data from the atmosphere and predicting future temperature and amount of gasses with the help of an Unmanned Aerial Vehicle (UAV) system. This system is designed as a comprised of sensors and database system. With the help of the drone which carries humidity sensor DHT11, gas sensors MQ2, MQ7, MQ135 along with temperature sensor TCH11, TCH22. The data that is needed for the further prediction will be collected by the help of these sensors. Node MCU will also be used. It will relate to Arduino Nano. With the help of Wi-Fi system all the data will be stored into a server. Based on the data, real-time graph for individual aspects will be plotted in an interface for better visualization, which will be helpful for monitoring and analysis. For the future prediction regression model is chosen and suggested values are compared. From the collecting values, if difference is much higher along with crossing the safe threshold limit. This proposal aims to identify the impact of "Green House" in a region and claims to raise awareness.

Keywords: Green house effect; linear regression analysis; UAV; NodeMCU; Gas Sensors;

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List of Acronyms

UAV	Unnamed aerial vehicle
MP	Mission Planner
APM	Ardupilot Mega
USB	Universal Serial Bus
GPS	Global Positioning System
GPIO	General Purpose Input Output
FTDI	Future Technology Devices International
UART	Universal Asynchronous Receiver Transmitter
SPI	Serial Peripheral Interface
ICSP	In Circuit Serial Programming

Chapter 1

Introduction

1.1 Motive of the thesis

In today’s world the burning problem is global warming. And the impact of this problem is very dangerous. Mainly, greenhouse gases are like blanket which covers the atmosphere completely. This layer performs a special task which is when small radiation from the sun comes through the layer it let the ray pass the barrier. But afterward when the ray tries to go back to the atmosphere it prevents it from going out thus the ray remain inside of the layer. And that procedure is repeating for hundreds of years. The large amount of sun ray that has been captured gradually increase the temperature of the environment. This is how the temperature of earth is increasing rapidly. Now as a matter of consequences, the temperature on earth is increasing so the ices on north pole and south pole is melting down, the big mountains which is standing on ice is melting gradually and for that reason the water level is increasing. The victim of the increasing water level would be the low-lying countries. Sooner or later these countries will go under water. On the other hand, the greenhouse gases which are water molecules, Carbon di-oxide, Carbon mono-oxide, Methane, Chloroform carbon (CFC), Nitrous oxide, ozone is being produced in our daily life very frequently. The smoke from transports, industrial wastes etc. are the sources of the production of greenhouse gases. Now in order to understand the condition of a area this thesis will work. And that was the motive to work on to build a system which can collect the data from environment and predict the future condition of the place.

1.2 Aim and Objectives

In this thesis UAV has been used. Which is a drone with special features. There are some sensors- humidity sensor DHT11, gas sensors MQ2, MQ7, MQ135 along with temperature sensor TCH11, TCH22. So, in a specific area when we set the drone it will go up and collect the data like- temperature, humidity, percentage of Carbon di-oxide, Carbon mono-oxide, Methane, Nitrous oxide and other gases of environment. Thus, by collecting this data continuously for some days a regression model can be generated. From the regression model by observing the pattern of change into the gases prediction of the future condition can be made for that area. And the good part is by observing the result necessary steps for that zone can be made like- planting trees on that site. As a result, the bad impact of global warming can be retreated.

1.3 Organization of thesis

This thesis paper consists of introduction, related works, design of UAV, comments, result, discussion and future works.

Firstly, in chapter one how the impact of global warming has motivated for the project, the overall aim and objective of the project are discussed.

Secondly, in chapter two all the previous works related to our project are attached along with proper citations.

After that, in chapter three the setup of UAV is shown primarily. APM is calibrated with MP software and the necessary parameters are checked. The UAV block diagram shows how the components are connected accordingly.

Next, in chapter four the components for the project is illustrated and briefly discussed. All the necessary functions and working parameters also have been added in short.

In chapter five result and discussion part is filled with all the information about the sensor data collection and communication protocols for each segment along data table and graphs.

In the last chapter, our plan and a brief conclusion have been added. Also, all the references have been attached from where all the researches were made for the project and used for various information.

Chapter 2

Related works

A lot of research in the field of UAV has already done by several teams such as interesting works in the academic environment where proposed by these following teams: Selcuk Bayraktar,Georgios E. Fainekos, and George J. Pappas from University of Pennsylvania presented a hybrid model of UAV of the Piccolo-controlled dynamics, coupled with the mode- (or waypoint (WP)) switching logic which is utilized in applying hybrid control methods in order to solve challenging problems involving multiple UAVs, such as synchronous or asynchronous formations, coordinated search and rescue, air-ground integration, and rapid emergency response. They tried deriving high-fidelity models that are validated with hardware-in-the loop simulations and actual experiments. Their models are hybrid, capturing not only the physical dynamics of the aircraft, but also the mode switching logic that supervises lower level controllers [1]. Another significant remark has been established by Hui-Ru Cao, Zhi Yang and Ye-Qian Li from Sun Yat-sen University, Guangzhou, China, they introduced to a wireless collection platform based on UAV which was used to test tension, rotational speed and the wind field. They performed practical application test using an MWSN which illustrates the feasibility of the platform. The UAV aims to address the increasing demand for wireless sensor network (WSN) distribution in different monitoring areas and enlarge the coverage for various application scenarios [2]. An interesting work with RAMA (Remotely operated Aerial Model Autopilot), an open control system for UAV which has developed angular rates stabilization was presented by Ondrej Spinka, Stepan Kroupa, Zdeněk Hanzálek and supported by the Ministry of Education of the Czech Republic. Their UAV represented Control algorithms, based on PI, LQG and SDRE approaches, focused on rotorcraft UAVs including a complex hierarchical autopilot design. They demonstrated Real data, measured during test-flights of an experimental UAV [3].

Another highly effective UAV has been in the center of the attention by the team of Tien-Yin Chou, Mei-Ling Yeh, Ying-Chih Chen, Yen-Hung Chen from Feng Chia University where they used UAV technology to provide applicable information and assistance in the field of disaster information collection and Base on this the UAV gets effective information at appropriate time and provide the reference for the phases of disaster-preparedness, response and return. The UAV is built of high mobility, high time-resolution and high image resolution and other features of unmanned vehicles to provide government important reference information in planning for disaster response and return [4]. A Witayangkurn a, M. Nagai b, K. Honda c, M. Dailey cR. Shibasaki introduced an UAV monitoring system for remote areas. They combined SOS (Sensor Observation Service) and SSG (Sensor Service Grid) platform as a medium of collecting data from the sensor nodes and received data afterwards. Different sensors were merged with a helicopter to make the overall structure and real time data was also collected by the aerial vehicle. With the help of UAV web platform real time data collection process was visible from a pc or mobile along with their access. Brooke Potter, Gina Valentino, Laura Yates, Thomas Benzing and Ahmad Salman came up with a UAV model where local water quality was detected by the WSN (Wireless Sensor Network). Three different nodes were connected to the main system for the purpose of collecting water temperature, pH and conductivity. The UAV was designed as a monitoring system with the help of WSN platform from IOT (Internet of things).

Most of the current existing research on UAV is based mainly on the design of the framework rather than research of the collected data to accomplish the main target of finding out whether the air is inhabitable or not. In this paper, research on the collected data has been demonstrated with real time graph based on accumulated data by the sensors. David Gallacher from Zayed

University has presented a paper on UAV where he mentioned the application of drone for monitoring the environment. He proposed to use IoT with drone to get better result. He also mentioned higher altitude for drone is better [6]. Raj Madhavan et al in their paper have also mentioned about drone. They used ECHAR 20A to capture different photos from the sky and then generate a mapping to predict future aspect about the land; like- whether it is suitable for agriculture or not. They also mentioned bigger sensor payload is much more suitable for mapping [7]. In another paper Daniele Ventura et al have mentioned about taking images by UAV and generate a mapping to get an idea about that region like coastal area. They have used the GPS technology to control the drone. IN the UAV there is a GPS receiver and by using this GPS coordinates of camera has been set to take pictures. These images have been saved to generate mapping [8]. A fantastic paper on UAV and its aspect on the city uses has been written by Farhan Mohammed et al. In their paper they mentioned the scope of using a UAV system to make a city more modern and smarter. Like – traffic control, security issues by capturing videos continuously in important area of the city, surveying activities of the cities, Hazardous situation like fire control, agricultural land surveying by mapping [9]. Jose isidro Hernandez vega et al on their paper has combined UAV with IoT system so that made more accurate and easier to collect data by DAQ system and generating a working model of it [10]. Mohamed Aboubakr, Ahmed Balkis, Ali-Abou ElNour, and Mohammed Tarique, their UAV can conduct air quality measurement at different altitudes that are hard to reach by conventional air quality monitoring system. In addition, the UAV can also measure the quality of water by collection water samples from on-shore and off-shore. Moreover, their focus was to make a low-cost UAV along with these measuring systems [11]. A group of remarkable people consisting of Miguel Alvarado, Felipe Gonzalez, Andrew Fletcher and Ashray Doshi from The University of Queensland they proposed the use of a UAV carring air quality sensors to allow precise characterization of blasting plumes in near-real time. In present field works most of the UAVs are failed to collect data in real time rather UAVs use predefined estimates of pollution sources and atmospheric conditions. On-board air quality sensors detect concentration of air particles where flight instrument data transmitted as telemetry from the UAV provides high resolution instantaneous micrometeorological data. In addition, the information of location, micrometeorological data, air quality can be delivered in real time to analytical software. The data stream has been used to feed flight-path-planning algorithms or atmospheric dispersion models in near real-time [12]. A team consisting of Marc Wehrhan and Philipp Rauneker from Leibniz Center for Agricultural Landscape Research and Micheal Sommer from University of Potsdam proposed a UAV representing as a successful approach of how to use the combination of UAV-based high-resolution remote sensing data and ground truth measurements for estimation of the total C export by harvest Lucerne. They used image pre-processing of the 12-band multispectral images which has led to a considerable reduction of noise and vignette effects [13]. From the team Tabbsum Mujawar and Lalasaheb Deshmukh from School of Physical Sciences, Solapur University, Solapur, Maharashtra, India, an environmental monitoring system was constructed with wired and wireless networks using least number of components and the focus is that it provides real-time monitoring data via money-spinning low data rate and significant power wireless communication technology. The team believes that even in the industrial sector this system can get enormous recognition [5].

Chapter 3

Design of UAV

UAV (Unmanned aerial vehicle) is commonly known as drone which assemblies an aircraft with aerial control system, a ground station and communication medium with the station and the vehicle is used worldwide for the military, scientific, agricultural or commercial works.

3.1 Working with UAV

The UAV is mainly built with several components so that it gives a swift control overall. This is four axis Quad Copter designed mainly for collecting data with the help of sensors and upload it to the server.

3.2 Components for UAV

1. DJI F450 Quadcopter Frame
2. A2212 1400KV For RC Aircraft Plane Multi copter Brushless Motor
3. 30A ESC Motor Speed Controller RC Brushless ESC
4. Ardupilot APM 2.6 Flight Controller
5. Ublox NEO-M8N GPS for APM
6. 3DR Radio Telemetry Kit 915Mhz Module
7. Power Module With 5.3V DC BEC – XT60
8. High Quality Glass Fiber Heighten Landing Gear Kit
9. Fly Sky FS-i6 2.4G 6CH Transmitter With FS-iA6B Receiver
10. Nylon Propeller 1045 10×4.5 (Black)
11. Wild Scorpion 5500mah 11.1V 30C lipo battery

3.3 Connecting the Components

Setting the APM is the first step. The firmware needs to be figured and the it has to be uploaded with the board and also the calibration of radio compass (how it behaves).The APM is really easy to use and the graphical interface is also very handicap is one of the newest platform which is reliable and provides great informational support for aerial upload and this can be dome at a low cost. The 2.6 APM board has a compass out of the main body and is connected to the GPS. For setting it up a USB cable is connected to the laptop and with the help of the mission planner software the radio channels can be connected properly. MP (mission planner) is downloaded and installed and after the installation process the board is connected via the USB cable to the computer. Going to the MP and making the initial setup is done secondly. What needs to be done after this is connecting the board to COM6(any USB port can be used) and after that install the firmware (list from the internet). After downloading the firmware, the type of vehicle needs to be chosen and all the hex files can be downloaded through the software. All this hex file is then uploaded to the board. The magnetometer and the accelerometer are set up. The Arduino mega is connected to the software and all the mandatory hardware setup can be controlled now. For the frame type X can is chosen and coming to compass calibration and performing live calibration (taking data points) the set up for compass is done. Again, for accelerometer placing the APM and clicking any key for the accelerometer calibration. Taking the 3DR (air) and connecting it properly for APM and checking the port the MP software would show 3DR radio in the optional settings. If both the radio (air and ground) are communicating properly to each other all the configuration data would show up. After setting all the parameters of 3DR both the radio will be ready to work.

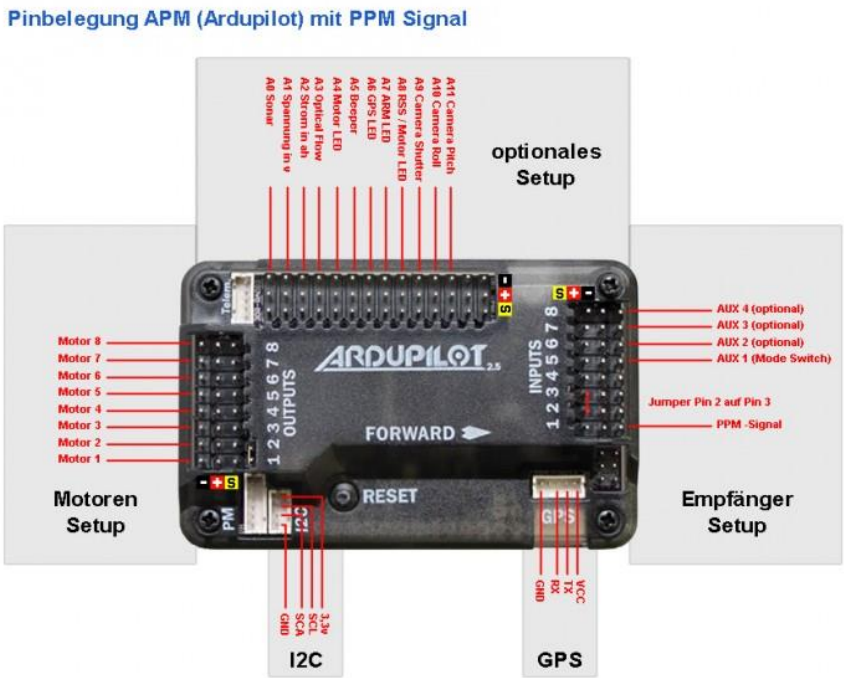


Figure 3.1: APM (Ardupilot) Pinouts [14]

Connecting DJI F450 Quad Copter Frames kits is the first step to build the main body of the vehicle. The frame is 2*6*10 inches and weighs around 1.02 pounds. The four-axis copter holds the main power system and the arms here are ESC installed and connected to the motors. For the power input APM 2.8 2.6 2.5 2.52 Power Module With 5.3V DC BEC – XT60 is being used. The connection needs to be done in the right way around. For connecting the motors ardupilot platform is used (connecting motors and RC). Checking for the four axes diagram the correct orientation can be found. The number of the motor and the servo must be matched. Then the ESC calibration is done by individual connection to the throttle channel and giving them high signal by the receiver. After that connecting them to the ESC. The process is also done for the throttle being back to zero. This is how they are individually calibrated.

In MP the terminal tab will show up if advanced view option is chosen. Initially from the terminal tab the option click is to be pressed and the code for APM will be uploaded via MP. Then adding motors in the coding section, the setup is ready to use.

For the flight modes, selecting the initial setup and then going to the flight modes the different options will appear in the screen. Some of the modes need GPS lock and other do not need the locking. Here stabilizes mode, altitude hold and one of the locked GPS mode is used. In Stabilized mode the throttle can manage the height and it also keeps the craft level. But here the wind can still push the UAV around. To avoid it the altitude, hold mode can be used as this mode helps to maintain any specific position, heading and height.

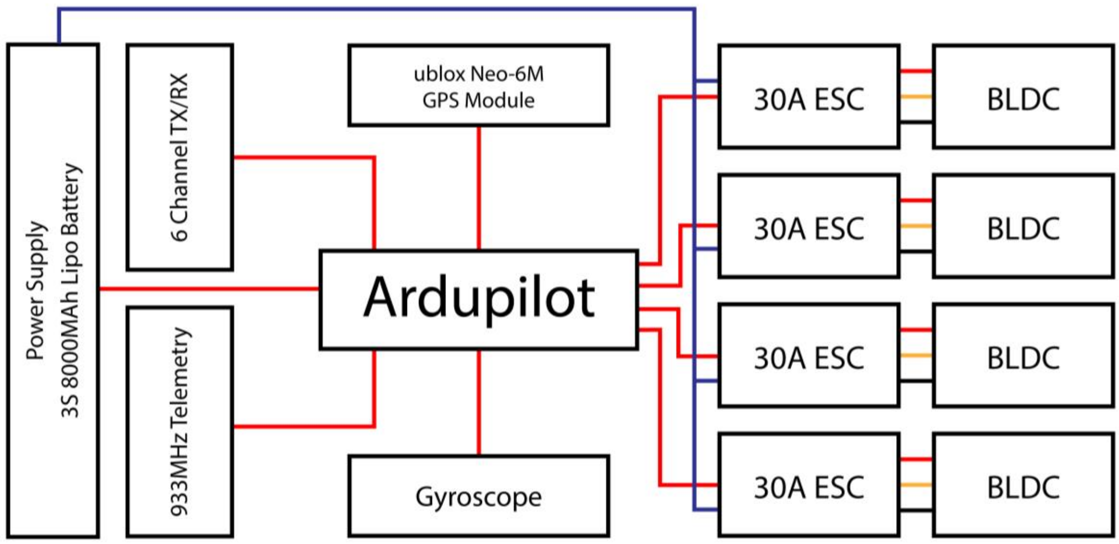


Figure 3.2: UAV Block Diagram

Chapter 4

Description of the Components

4.1 DHT11

This particular sensor works for detecting temperature and humidity at the same time. It gives digital output data which is its most attractive part. It gives the temperature data from 0 to 50 degree Celsius. The accuracy of temperature data is also very good. Besides, the humidity data has only 2% of error rate. The response time is also very recommendable. Lowest response time is 6s and highest up to 30s.

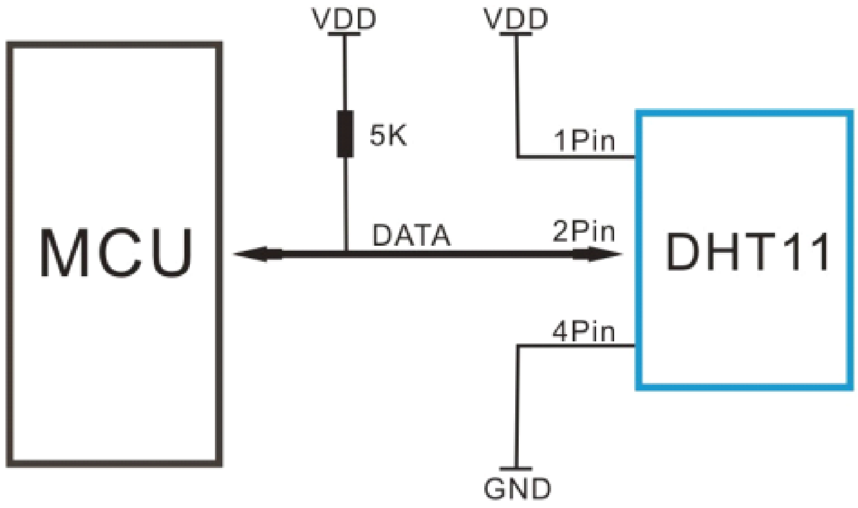


Figure 4.1: Typical application of DHT11 [15]

If the connecting cable is less than 20 meters, a 5 K pullup resistor is recommended; if the co nnecting cable is longer than 20 meters, pick a suitable pull-up resistor as required.

4.2 Arduino

The Arduino is a very popular microcontroller-based CPU. We use Arduino Nano for this project. One of the main reasons of using Arduino Nano is that it is very small so we can easily fit it in our designed UAV. We use the ATmega328P (Arduino Nano 3.x) model.

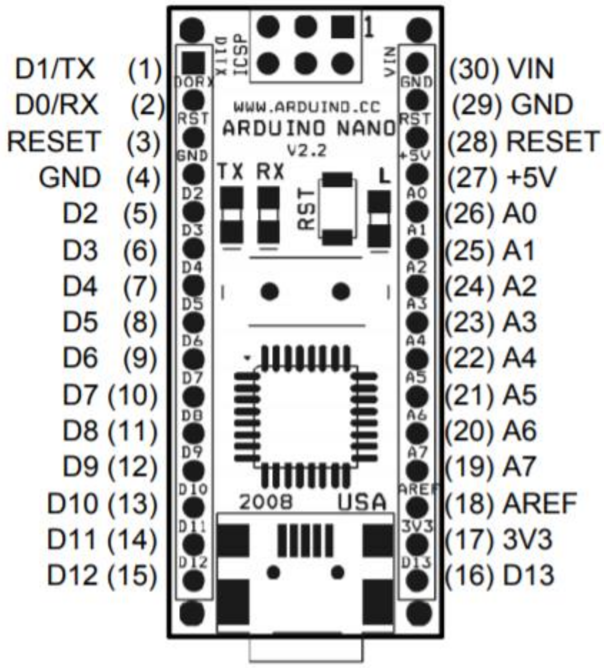


Figure 4.2: Arduino Nano Pinout [16]

Arduino Nano has 22 pins in total. Among those 8 pins are analog. Those works as input pin. Rest of the pins are digital pins and all of the pins work as output. It needs 5V power supply to work on. We collect data from the gas sensors by using Arduino, later the data is sent to NodeMCU.

It has a built-in memory and data storage which help it to work more efficiently and swiftly. It uses various ways and protocols to contact with other devices.

4.3 NodeMCU (ESP8266)

Figure 4.3: ESP8266 NodeMCU Development Board [17]

We use NodeMCU to collect data from the Arduino which are previously collected from the gas sensors. The main feature of NodeMCU is it has a built In Wi-Fi in it. So, it can easily be connected with other devices within its premises Wi-Fi range. It is a very much breadboard friendly component as well.

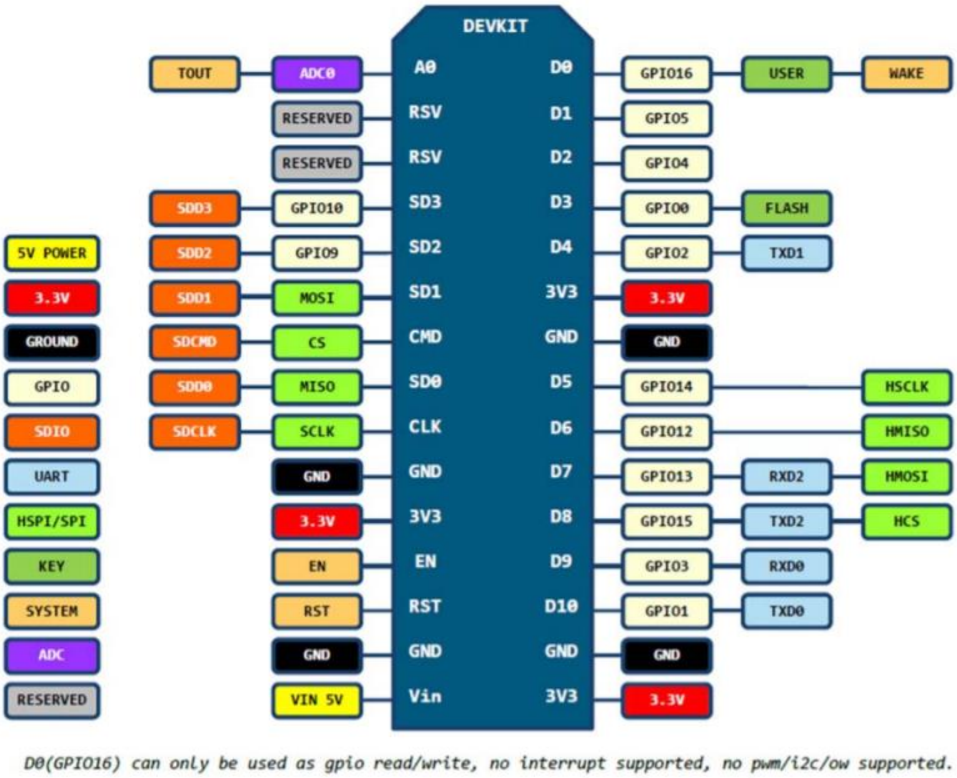


Figure 4.4: ESP8266 NodeMCU Development Board Pinout [17]

It has Kbytes memory and 4 Mbytes of storage. Having these fundamental features, it has become a very good open source IoT platform.

4.4 LoRa (Long Range) E32-TTL-100

Figure 4.5: LoRa E32-TTL-100 [18]

LoRa is one of the most important components of this thesis project. There are a lot of communication devices available in the market but LoRa was chosen for two main reasons, one for its ling range accuracy and another is its ultra-low power consumption. LoRa means long range. So, it maintains communication in a long range.

It uses UHF (Ultra High Frequency) band for its communication medium. Its uses 410 MHz to 441 MHz and its default is always to set to 433 MHz. It uses broadcast transmission system. Half duplex communication system is used for its communication purpose that means it can both send and receive data, but it cannot do it at the same time. So, it has both TX and RX pin.

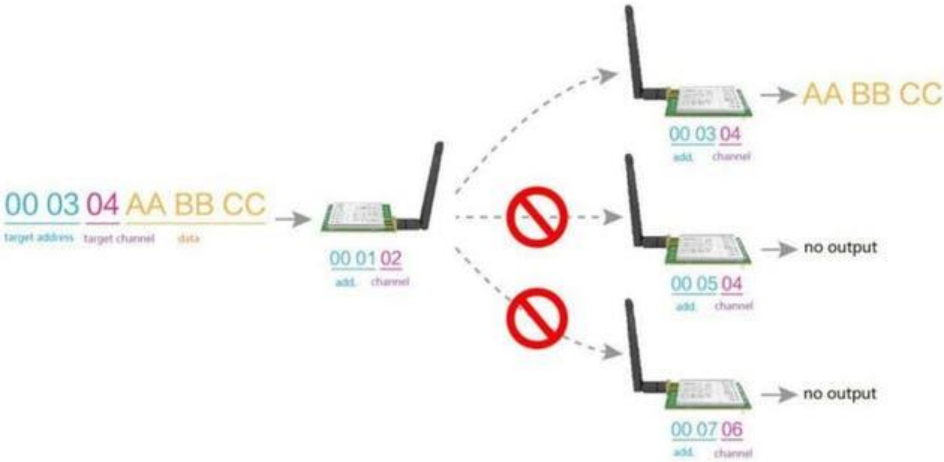


Figure 4.6: Fixed Transmission Mode [19]

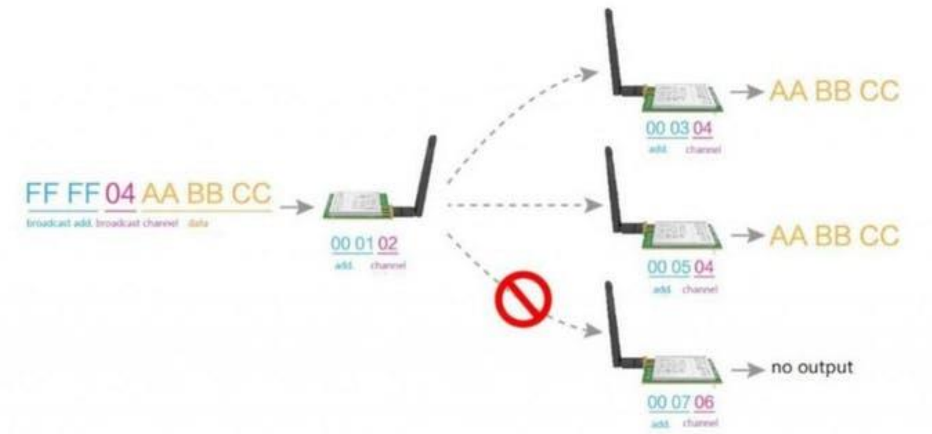


Figure 4.7: Broadcast Transmission Mode [19]

LoRa has four different modes to work. In normal mode, its combination is 00. In waking up mode its combination is 01 while its combination is 10 in working mode. 11 is the combination for the sleep mode. Working mode is also called the power saving mode.

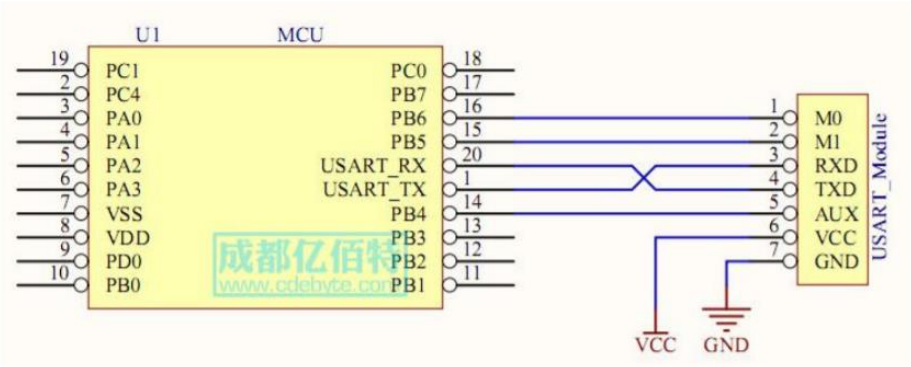


Figure 4.8: LoRa and MCU Connection [20]

4.5 MQ-2

Touchy material of MQ-2 gas sensor is SnO2, which with lower conductivity in clean air. When the target burnable gas exists, the sensor's conductivity is progressively higher alongside the gas focus rising.

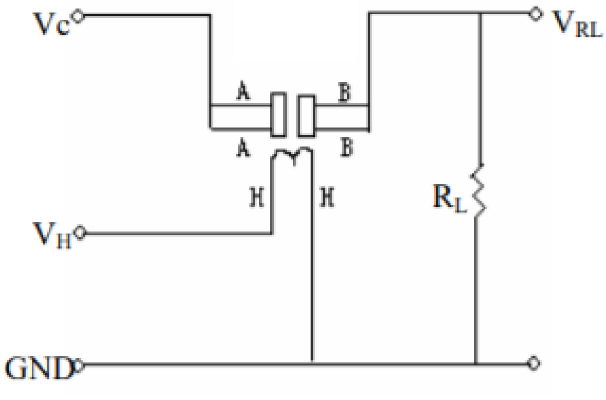


Figure 4.9: MQ-2 Test Circuit Diagram [21]

4.6 MQ-7

Touchy material of MQ-7 gas sensor is SnO_2, which with lower conductivity in clean air. It makes recognition by strategy for cycle high and low temperature and distinguish CO at low temperature (heated by 1.5V). The sensor's conductivity gets higher alongside the CO gas focus rising. At high temperature (heated by 5.0V), it cleans different gases adsorbed at low temperature. Clients can change over the difference in conductivity to relate yield sign of gas focus through a straightforward circuit.

The sensor requires two voltage inputs: warmer voltage (VH) and circuit voltage (VC). VH is utilized to supply standard working temperature to the sensor and it can embrace DC or AC control. For this model sensor, VH ought to be at 1.5V±0.1V low voltage when distinguish CO while ought to be at 5V±0.1V at nonidentification status (resuming period). VRL is the voltage of burden obstruction RL which is in arrangement with sensor. Vc supplies the recognize voltage to stack opposition RL and it ought to receive DC control.

4.7 MQ-135

Structure and arrangement of MQ-135 gas sensor is formed by small scale AL_2O_3 fired cylinder, Tin Dioxide (SnO_2) delicate layer, estimating cathode and radiator are fixed into a covering made by plastic and tempered steel net. The warmer gives essential work conditions to work of touchy segments. The encompassed MQ-135 have 6 pins ,4 of them are utilized to bring signals, and other 2 are utilized for giving warming current.

Chapter 5

Result & Discussion

5.1 Sensor Data Collection

Along with the UAV (Unmanned Aerial Vehicle) we have designed and implemented a data collection and communication device. We have divided our device into two separate section. The sections are:

1. Data collection using the sensor
2. Communication

We have collected the data of temperature, humidity and different types of gases in the air. We have also divided our communication into two different part.

1. Server based communication
2. Radio communication

We have already mentioned that we have used DHT11 for measuring temperature and humidity, MQ-2, MQ-7, MQ-135 for detecting the gas and measure air quality. Our hardware section consists of Arduino Nano, NodeMCU, Wi-Fi Hotspot and LoRa Module. We have used Wi-Fi hotspot to provide internet connectivity to NodeMCU and LoRa to create the communication network through radio frequency. MQ-2, MQ-7, MQ-135 are analog sensors. These sensors provide analog values from 0-1023. Theses sensors also have the option for a digital value which is dependent on a potentiometer. We took the reading through the analog pins of Arduino Nano. For three gas sensors we used three separate analog pins of Arduino Nano.

5.2 Arduino and NodeMCU Communication

We could only use NodeMCU to take the readings, but the limitation is that the NodeMCU has only one analog pin to take analog reading. So, we must move to Arduino Nano for taking the sensor data. Then we used the Digital Pin for DHT11. We used a library named dht11.h for getting the temperature and humidity from the sensor. We took all the data reading from sensor to Arduino. In Arduino we have programmed it in such a way so that the data can be passed as one string. After collecting all data using Arduino, we passed the data to NodeMCU through TX and RX. We used a library named Software Serial. Software serial is used for serial communication through digital pins. Using this library, we can define which pin will be used as RX and which pin will be used as TX. By this method we transferred our data from Arduino Nano to NodeMCU.

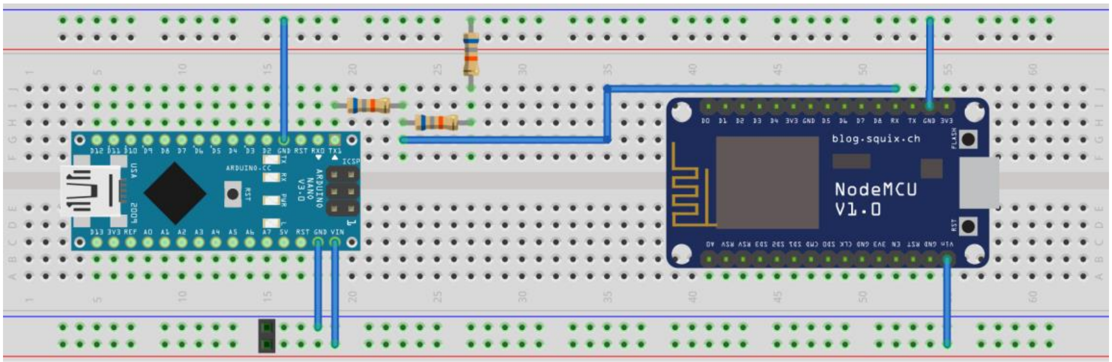


Figure 5.1: Arduino & NodeMCU Communication [22]

In NodeMCU we received the data passed from Arduino. After receiving the data in NodeMCU we began with the communication section. We handled one of our communication through NodeMCU and another one through Arduino. For uploading data to data server, we used NodeMCU as NodeMCU has a built-in WIFI chip for internet connectivity.

5.3 Setting up the server for receiving data

Before uploading data to server, we had to setup our server with the latest possible technologies. We have used a Virtual Private Server (VPS) for receiving our data from NodeMCU. In the virtual private server, we need to configure everything according to our need. In the server we had a dedicated IP to access it. Also, the server has a dedicated internet connectivity. We have used Apache as a Server Software. Then we configured the MySQL database for logging the data. We have also set up firewall in our server. Then we installed Node Red in our server which is the node to receive the data.

Figure 5.2: LAMP Stack for setting up the server [23]

Node red supports different types of IoT technologies to receive and transmit data. We have used the MQTT protocol to receive data from NodeMCU. For MQTT protocol, we used the Mosquitto MQTT Broker with username and password-based authentication.

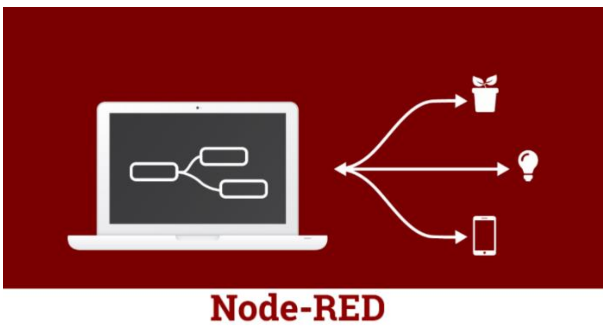


Figure 5.3: Node-RED & Mosquitto MQTT Broker [24][25]

We installed the broker in our server and connected the broker to NodeMCU using the server IP. Once the connection is set up, we logged in to node-red dashboard. In Node Red everything works based on the flow. We created a flow to receive data from NodeMCU. Here is a sample data flow diagram of how Node Read creates its network and transmits data.

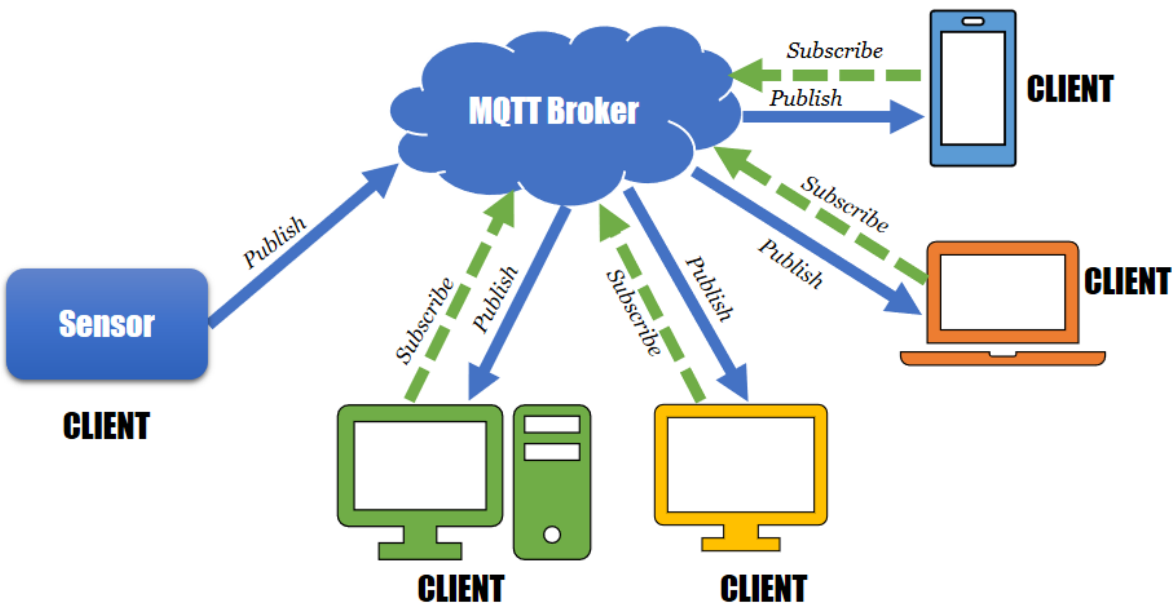


Figure 5.4: Data Transmission Flow Diagram for MQTT Broker [26]

5.4 Database configuration

After successful setup, we started receiving the data from NodeMCU. After receiving the data, we split them in different sections and then upload them to our MySQL database. To insert data in MySQL database, we used PHP. PHP is a server-side scripting language. We have written a script which uploads the data to database as soon as it receives it.

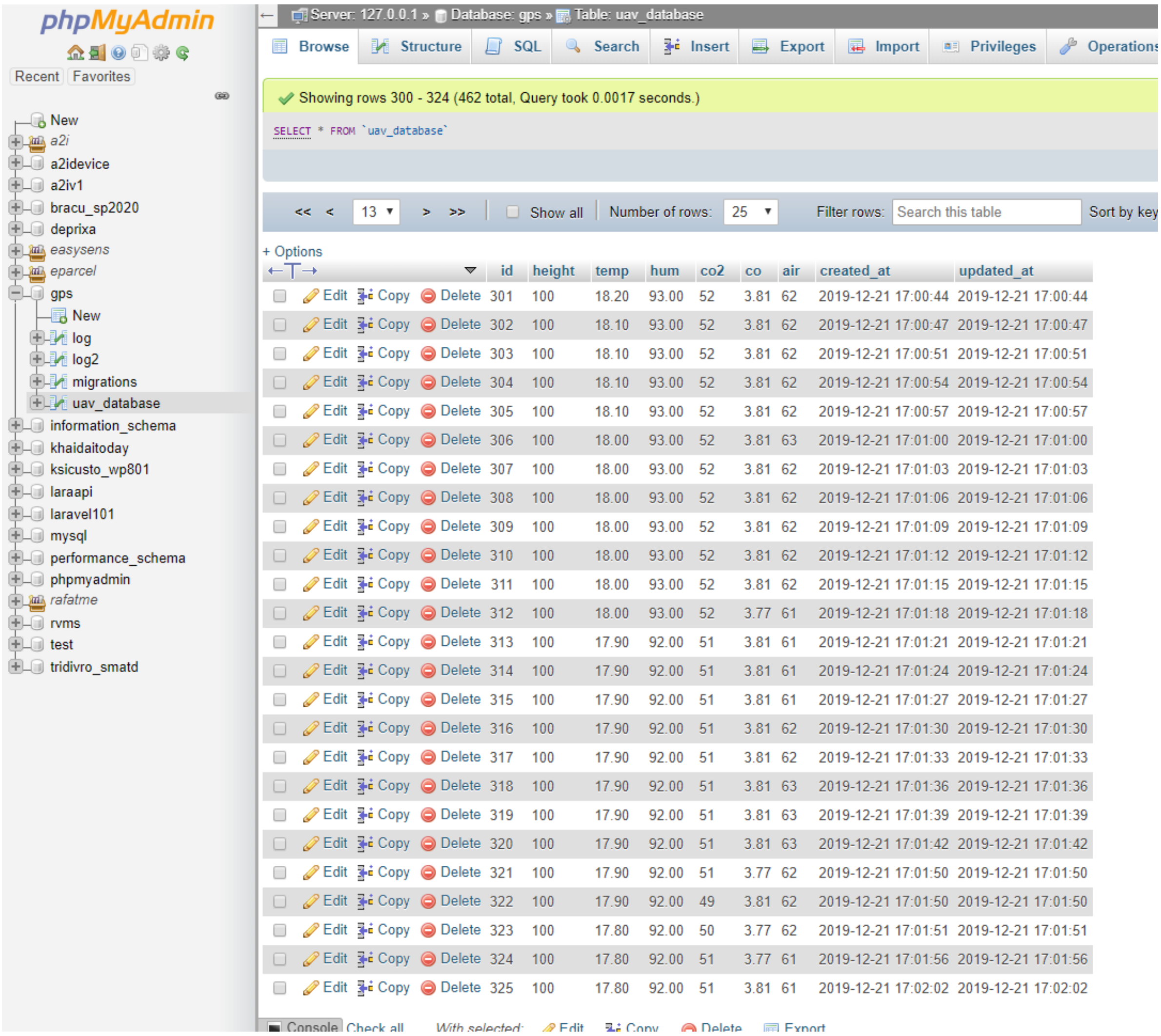


Figure 5.5: MySQL Database User Interface

5.5 Radio Data Transmission & Data Log

Using this LoRa module and using the broadcast transmission method we transmitted the data drone the Arduino. Now to receive the data we also need a ground module. Our ground module which is basically LoRa RX. This module receives the message from the LoRa and respond accordingly. We have used the Arduino serial monitor to check the data. We have also developed an UI with Unity which receives the data from LoRa ground station. In the GUI we have represented the data that we have been collection. We have also separate log file for each data. From the log we can get the data for our future works.

5.6 Collected Data from UAV (Uttara)

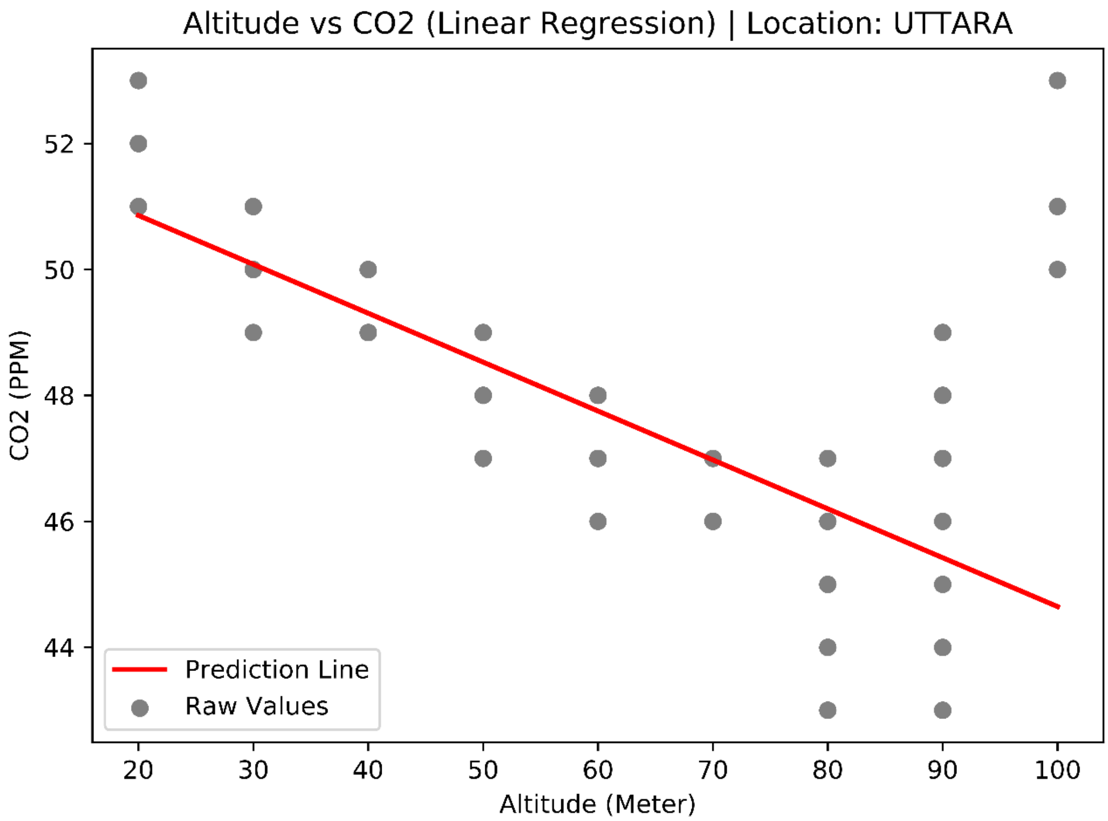
SN	Altitude (meter)	Temperature (Celsius)	Humidity (%)	CO2 (PPM)	CO (PPM)	Air Quality
1	20	18.20	93.00	53	3.81	63
		18.10	93.00	52	3.81	62
		18.10	93.00	52	3.81	62
		18.00	93.00	52	3.81	62
		18.00	93.00	52	3.77	61
2	30	17.90	92.00	51	3.81	61
		17.90	92.00	51	3.81	62
		17.90	92.00	51	3.81	63
		17.80	92.00	51	3.77	61
		17.80	92.00	49	3.84	59
3	40	17.70	92.00	49	3.84	58
		17.70	92.00	49	3.84	58
		17.60	92.00	48	3.84	58
		17.60	92.00	48	3.81	58
		17.50	92.00	48	3.84	58
4	50	17.50	92.00	48	3.81	58
		17.50	92.00	48	3.81	58

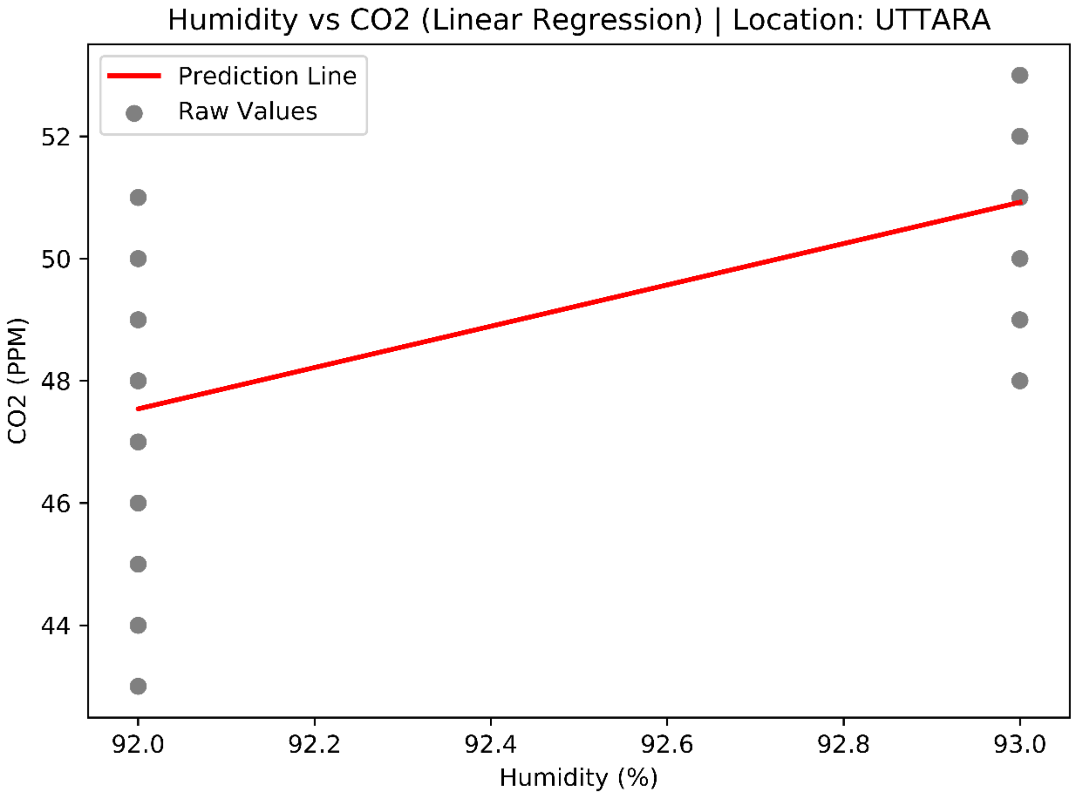
		17.50	92.00	48	3.81	59
		17.40	92.00	48	3.81	58
		17.40	92.00	48	3.84	57
5	60	17.40	92.00	48	3.84	57
		17.40	92.00	47	3.84	56
		17.40	92.00	47	3.81	56
		17.40	92.00	47	3.81	55
		17.30	92.00	47	3.81	55
6	70	17.40	92.00	46	3.77	54
		17.40	92.00	46	3.81	54
		17.40	92.00	46	3.81	53
		17.40	92.00	46	3.77	53
		17.40	92.00	45	3.77	53
7	80	17.20	92.00	45	3.74	52
		17.30	92.00	44	3.74	52
		17.30	92.00	44	3.77	54
		17.40	92.00	44	3.77	53
		17.30	92.00	44	3.84	53
8	90	17.30	92.00	44	3.91	52
		17.30	92.00	44	3.95	52

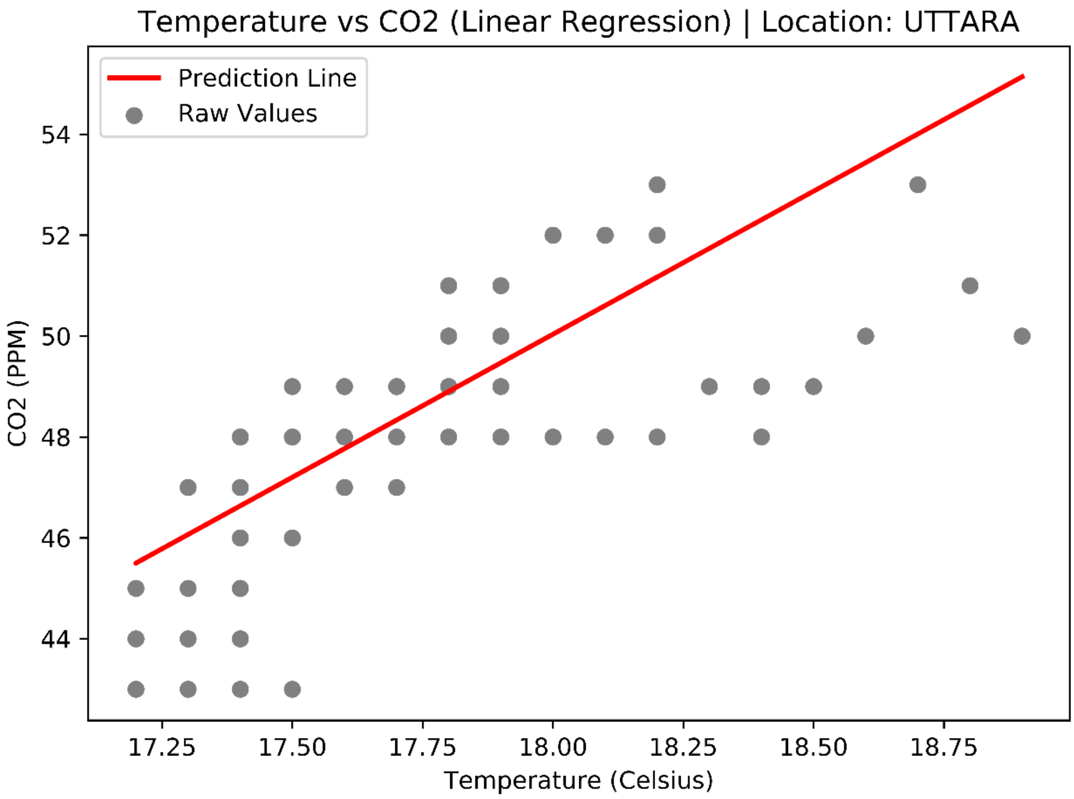
		17.30	92.00	44	3.95	52
		17.30	92.00	43	3.98	51
		17.50	92.00	43	3.98	51
9	100	17.40	92.00	43	3.98	51
		17.40	92.00	45	4.02	53
		17.50	92.00	46	4.12	55
		17.60	92.00	47	4.19	55
		17.70	92.00	47	4.29	56
10	110	17.60	92.00	47	4.19	55
		17.70	92.00	47	4.29	56
		17.70	92.00	48	4.36	56
		17.80	92.00	48	4.39	56
		17.90	92.00	48	4.43	56

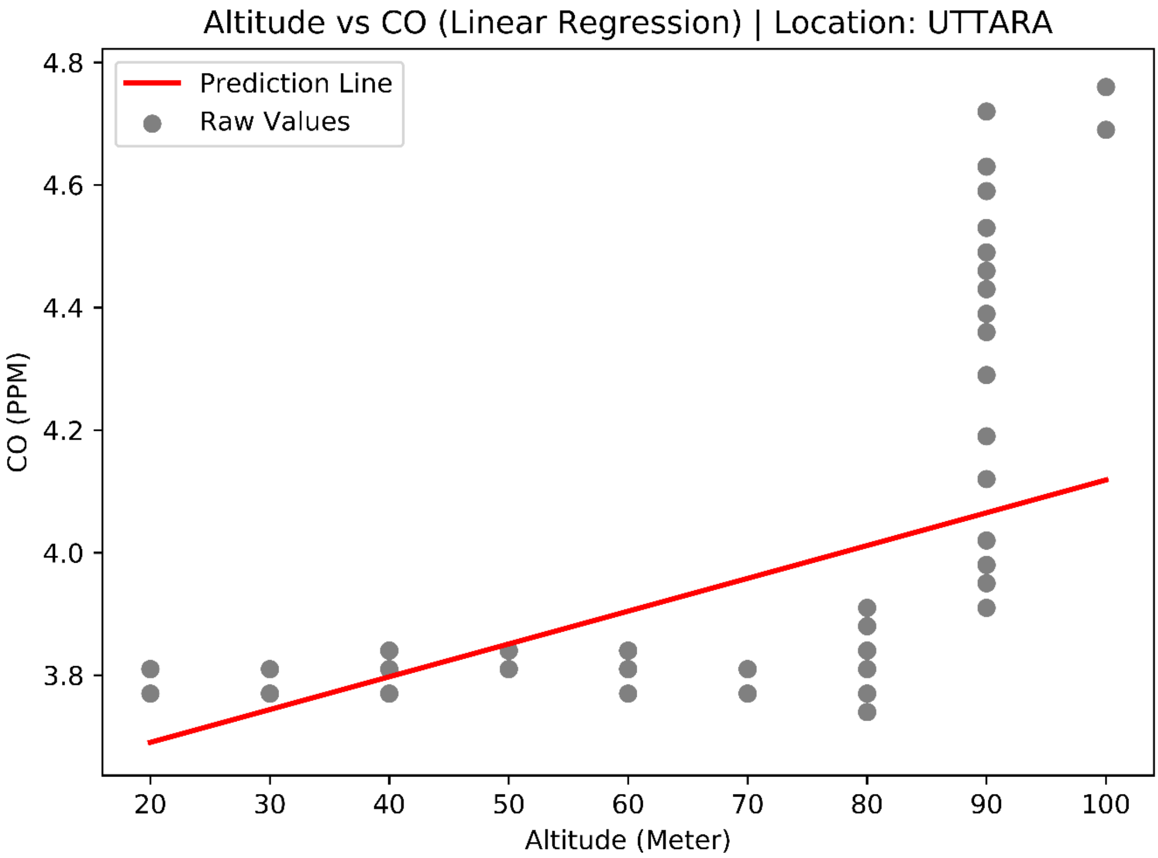
5.7 Best Fit Linear Regression Model for Uttara

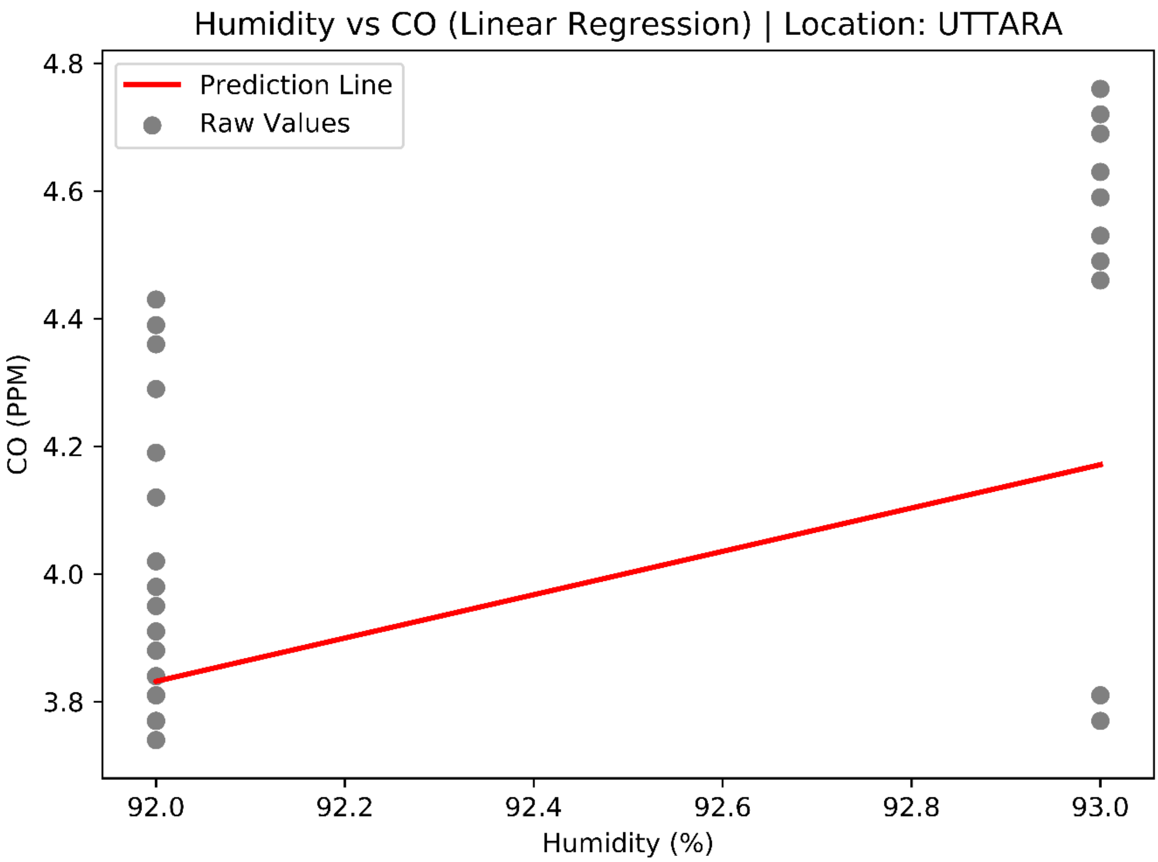
Here is observation of best fit linear model for Uttara area which includes (CO_2, CO, air quality) vs. altitude, (CO_2, CO, air quality) vs. Humidity and (CO_2, CO, air quality) vs. temperature.

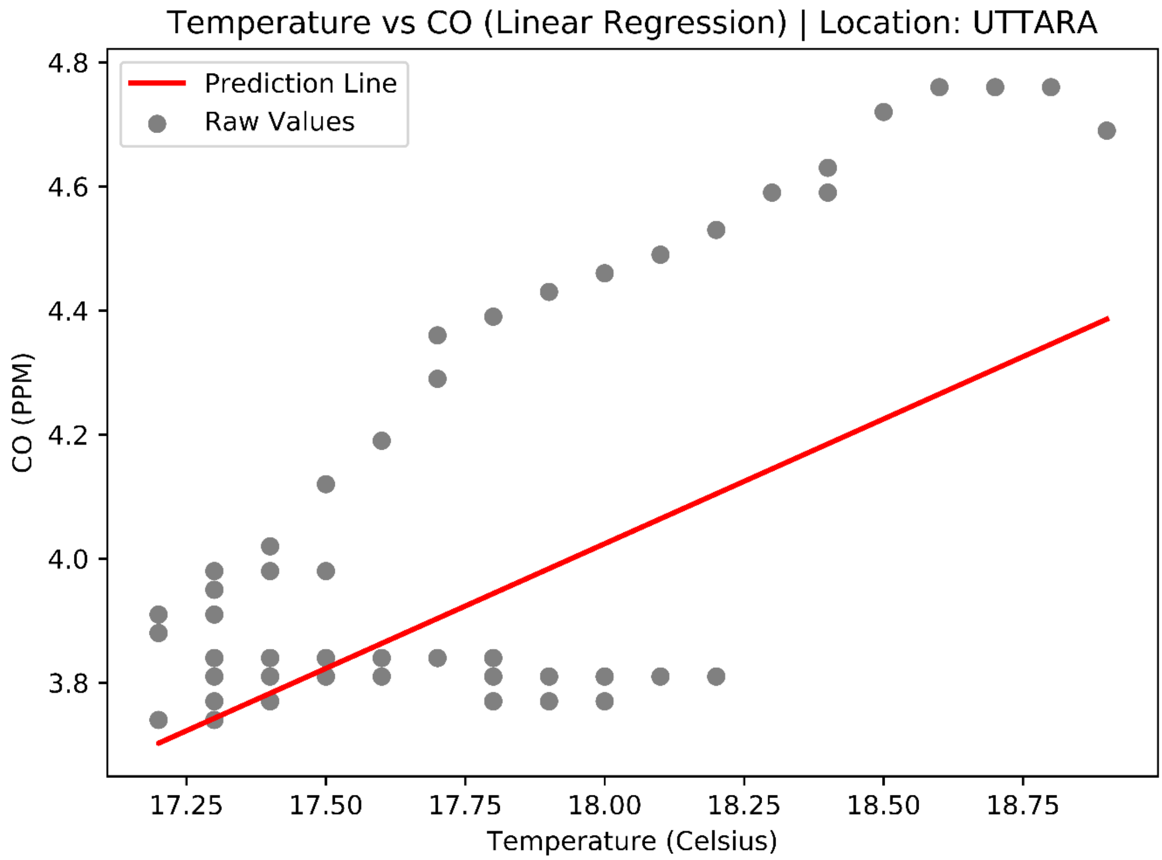


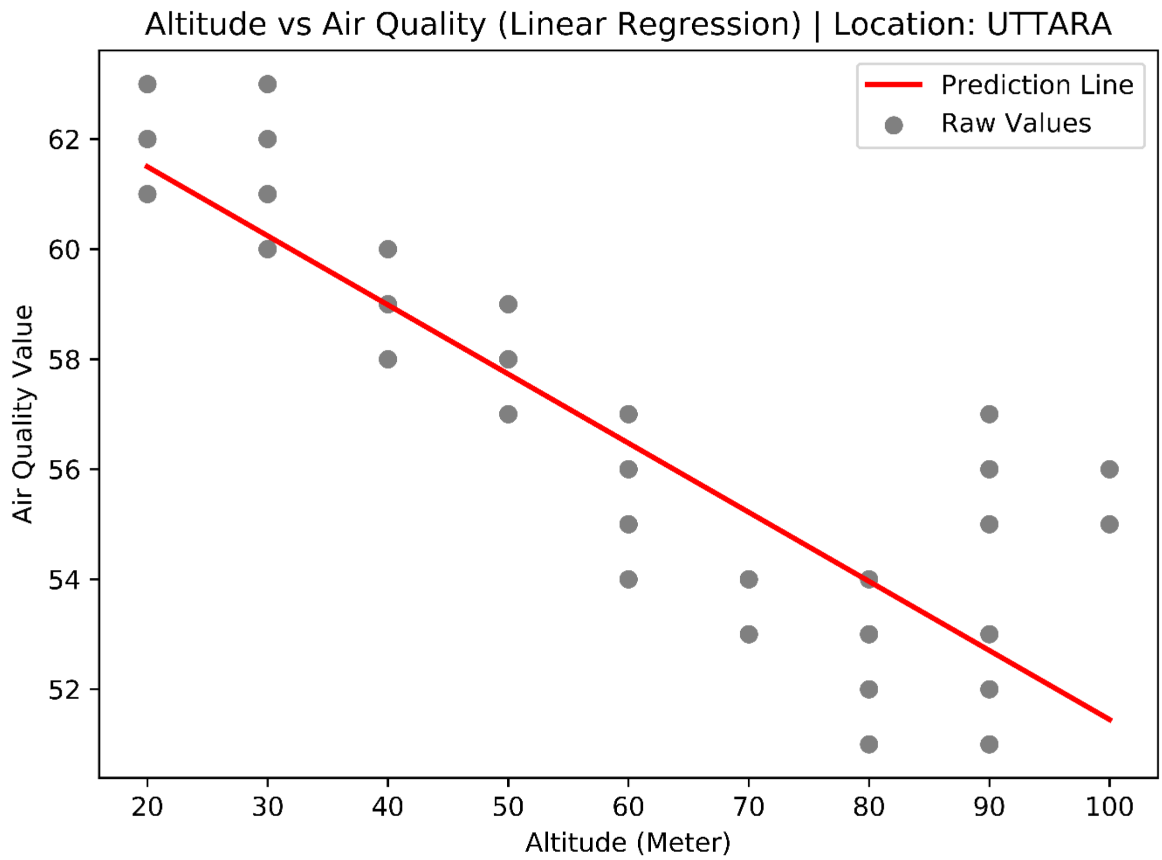

Humidity vs CO2 (Linear Regression) | Location: UTTARA
Prediction Line
Raw Values
CO2 (PPM)
Humidity (%)
52
50
48
46
44
92.0
92.2
92.4
92.6
92.8
93.0

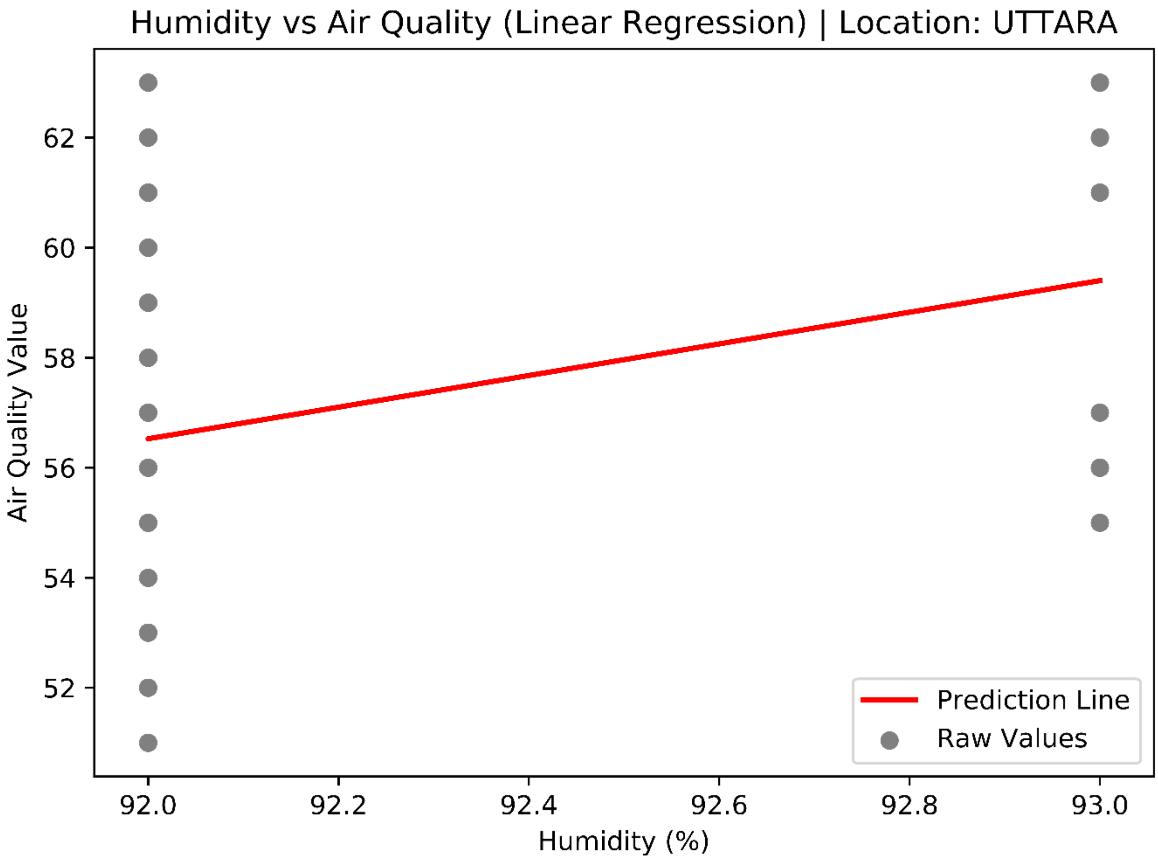

Temperature vs CO2 (Linear Regression) | Location: UTTARA
Prediction Line
Raw Values
CO2 (PPM)
Temperature (Celsius)
54
52
50
48
46
44
17.25
17.50
17.75
18.00
18.25
18.50
18.75

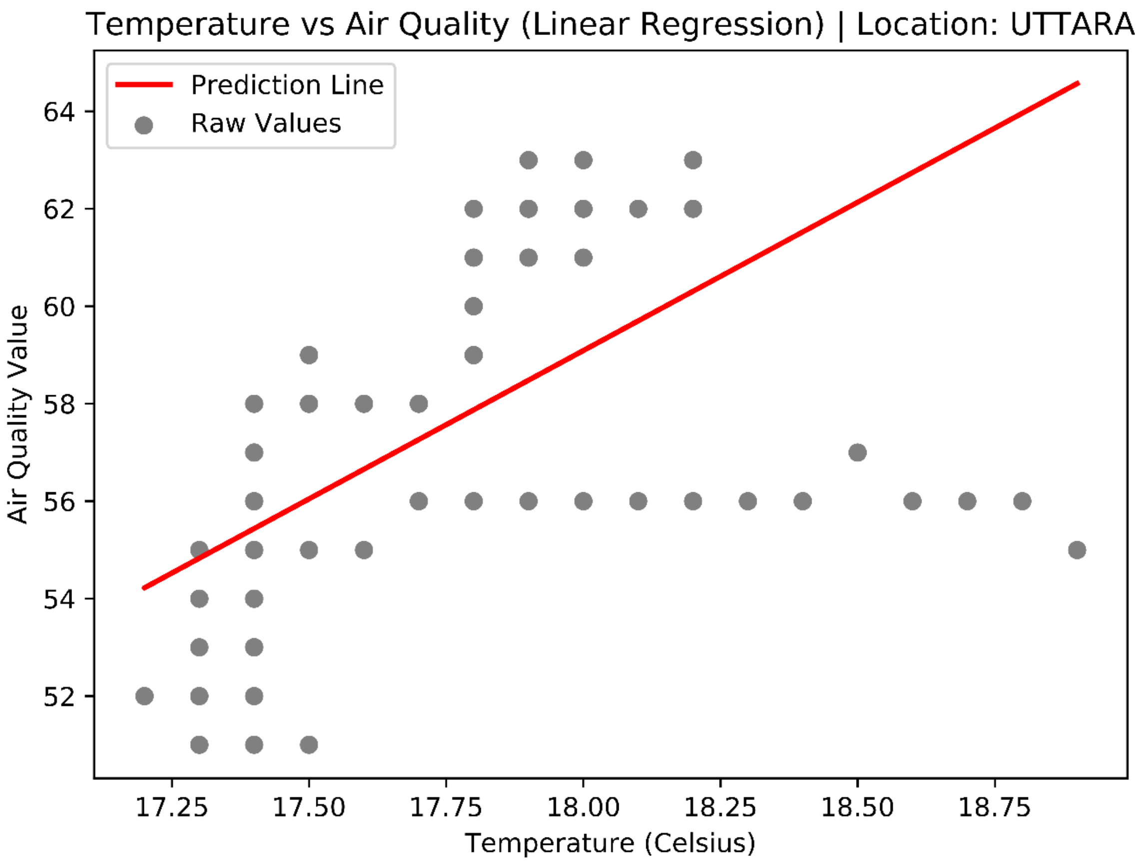

Altitude vs CO (Linear Regression) | Location: UTTARA
Prediction Line
Raw Values
CO (PPM)
4.8
4.6
4.4
4.2
4.0
3.8
20
30
40
50
60
70
80
90
100
Altitude (Meter)


Humidity vs CO (Linear Regression) | Location: UTTARA
Prediction Line
Raw Values
CO (PPM)
4.8
4.6
4.4
4.2
4.0
3.8
92.0
92.2
92.4
92.6
92.8
93.0
Humidity (%)


Temperature vs CO (Linear Regression) | Location: UTTARA
Prediction Line
Raw Values
4.8
4.6
4.4
4.2
4.0
3.8
CO (PPM)
17.25
17.50
17.75
18.00
18.25
18.50
18.75
Temperature (Celsius)


Altitude vs Air Quality (Linear Regression) | Location: UTTARA
Prediction Line
Raw Values
62
60
58
56
54
52
Air Quality Value
20
30
40
50
60
70
80
90
100
Altitude (Meter)


Humidity vs Air Quality (Linear Regression) | Location: UTTARA
Air Quality Value
Humidity (%)
Prediction Line
Raw Values
62
60
58
56
54
52
92.0
92.2
92.4
92.6
92.8
93.0


Temperature vs Air Quality (Linear Regression) | Location: UTTARA
Air Quality Value
Temperature (Celsius)
Prediction Line
Raw Values
64
62
60
58
56
54
52
17.25
17.50
17.75
18.00
18.25
18.50
18.75

5.8 Collected Data from UAV (Aftabnagar)

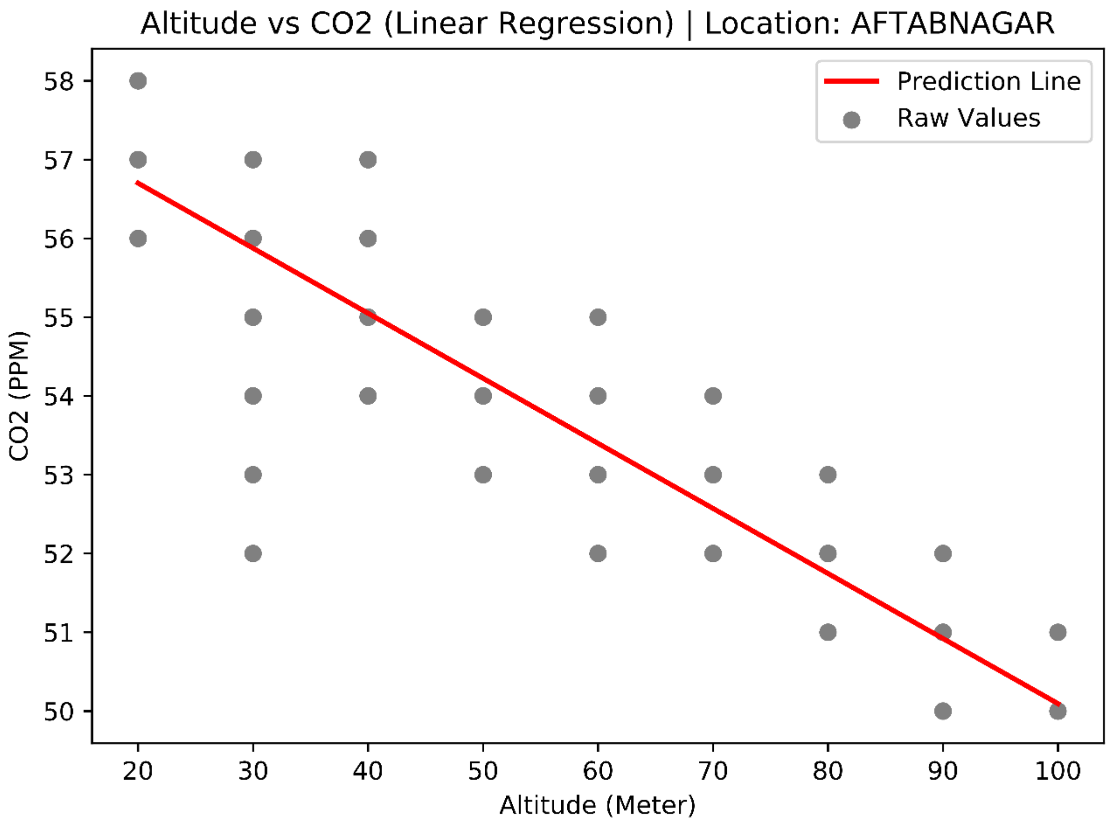
SN	Altitude (meter)	Temperature (Celsius)	Humidity (%)	CO2 (PPM)	CO (PPM)	Air Quality
1	20	18.1	90	56	3.85	62
		18	90	56	3.85	61
		18.1	90	56	3.86	62
		18	91	57	3.86	62
		18	90	57	3.86	63
2	30	17.8	89	52	3.85	58
		17.8	88	53	3.85	58
		17.8	87	54	3.85	59
		17.8	87	54	3.86	58
		17.8	87	54	3.87	58
3	40	17.7	90	57	3.84	56
		17.7	89	57	3.86	56
		17.7	88	56	3.84	57
		17.7	88	55	3.84	56
		18	89	55	3.84	56
4	50	18.1	91	55	3.85	55
		18.2	91	54	3.85	55

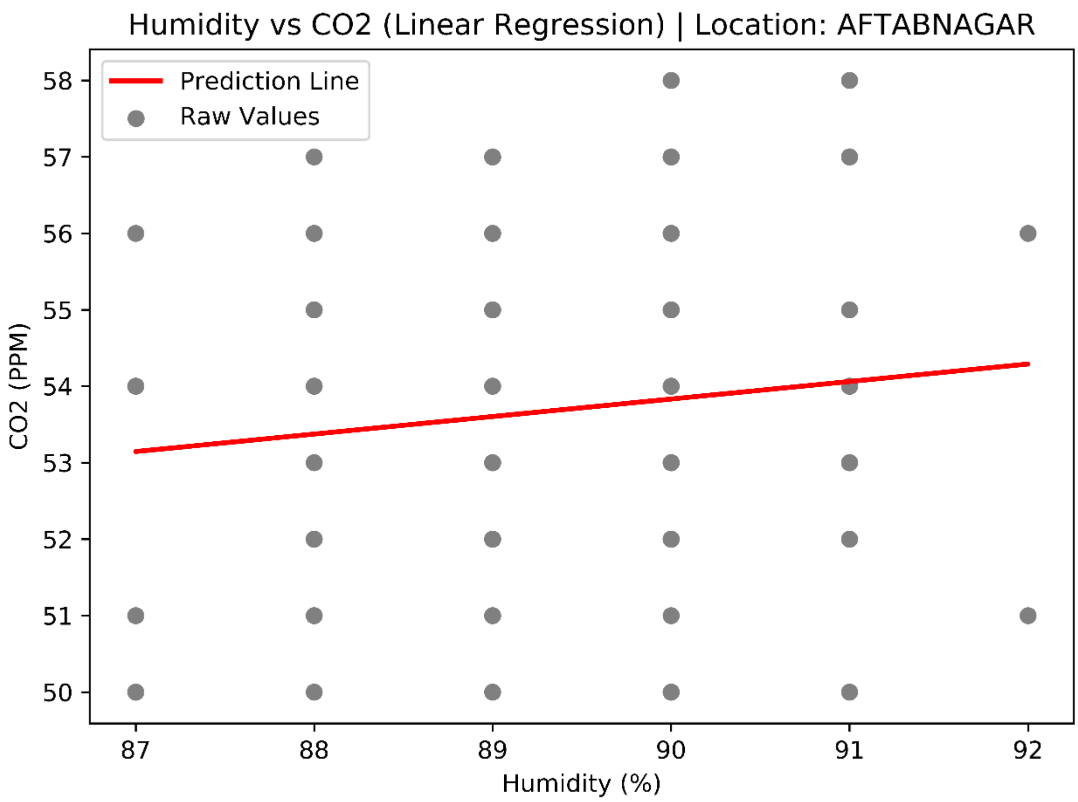
		18.2	91	53	3.85	56
		18.1	91	53	3.84	56
		18.2	90	55	3.84	55
5	60	18.4	90	53	3.82	54
		18.3	91	53	3.81	54
		18.3	90	53	3.82	54
		18.2	91	53	3.81	54
		18.1	90	52	3.81	54
6	70	18.1	90	53	3.81	53
		18.1	90	53	3.82	53
		18.2	91	53	3.82	52
		18.2	91	52	3.82	52
		18.1	91	52	3.82	52
7	80	17.3	89	51	3.84	51
		17.2	89	51	3.85	52
		17.2	88	52	3.85	52
		17.2	88	52	3.86	52
		17.2	88	51	3.85	51
8	90	17.7	87	50	4	17.7
		17.7	87	50	4	17.7

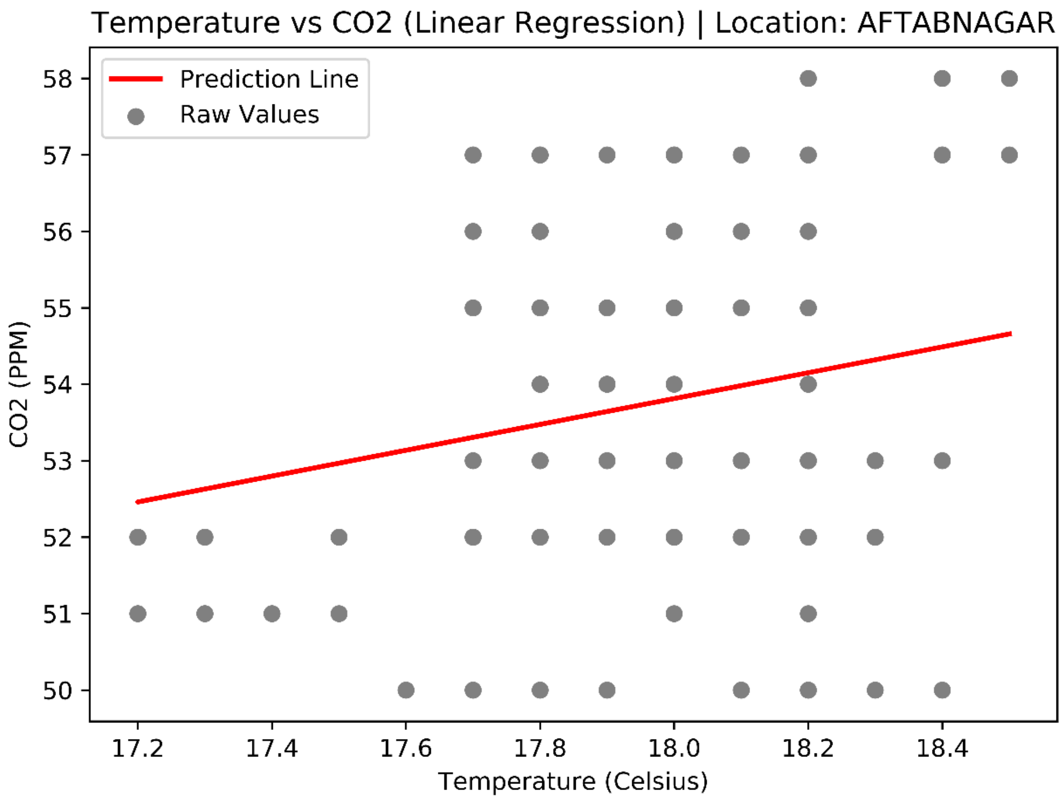
		17.8	87	50	3.9	17.8
		17.9	87	50	3.89	17.9
		18.1	89	52	3.87	18.1
9	100	17.40	92.00	43	3.98	51
		17.3	89	51	3.84	51
		17.2	89	51	3.85	52
		17.2	88	52	3.85	52
		17.2	88	52	3.86	52
10	110	17.60	92.00	47	4.19	55
		17.8	89	52	3.82	51
		17.7	89	53	3.82	51
		17.8	90	52	3.81	51
		17.7	90	52	3.82	52

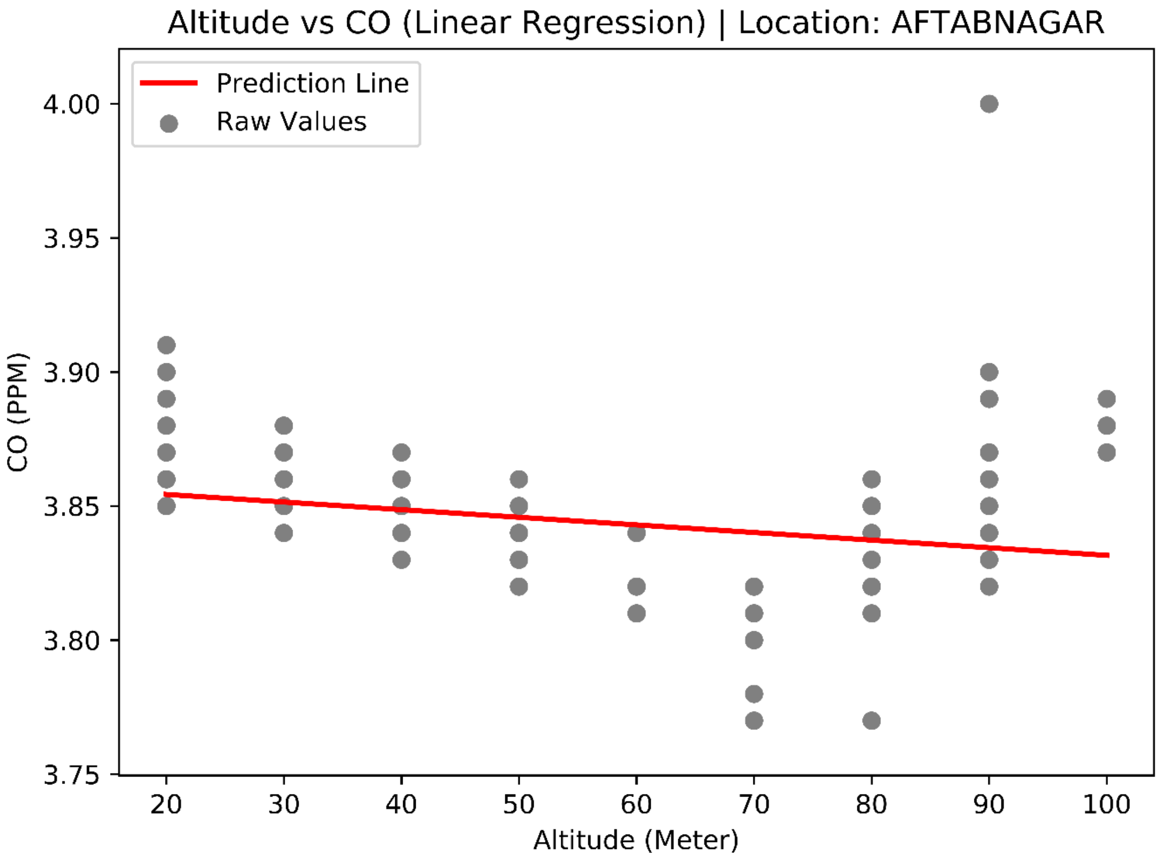
5.9 Best Fit Linear Regression Model for Aftabnagar

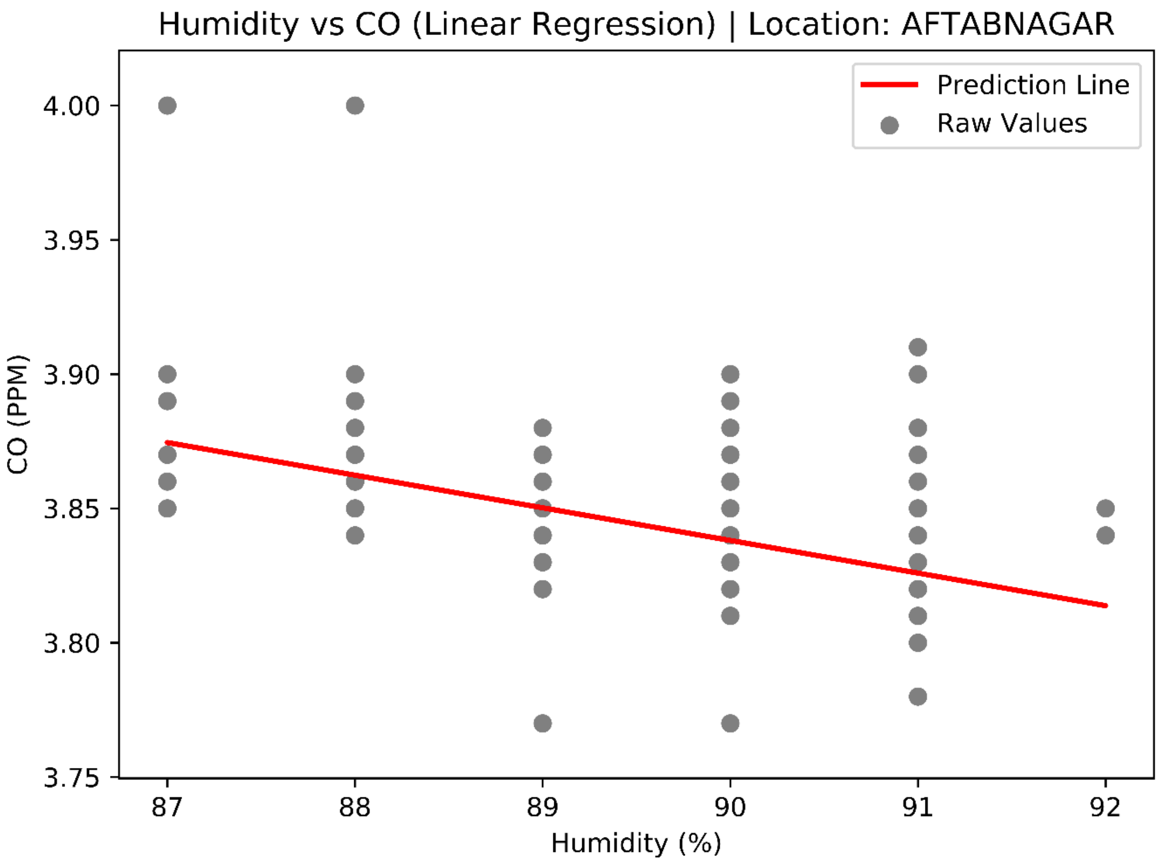
Here is observation of best fit linear model for Aftabnagar area which includes (CO_2, CO, air quality) vs. altitude, (CO_2, CO, air quality) vs. Humidity and (CO_2, CO, air quality) vs. temperature.

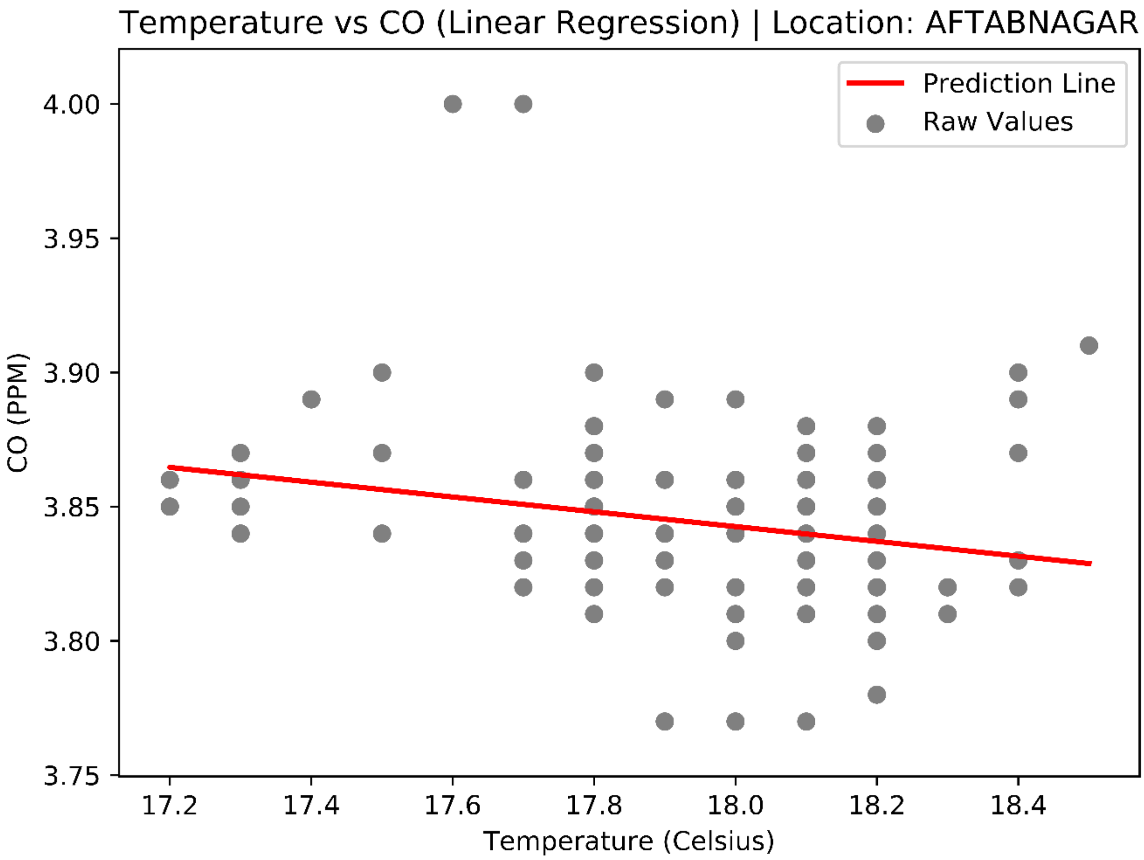


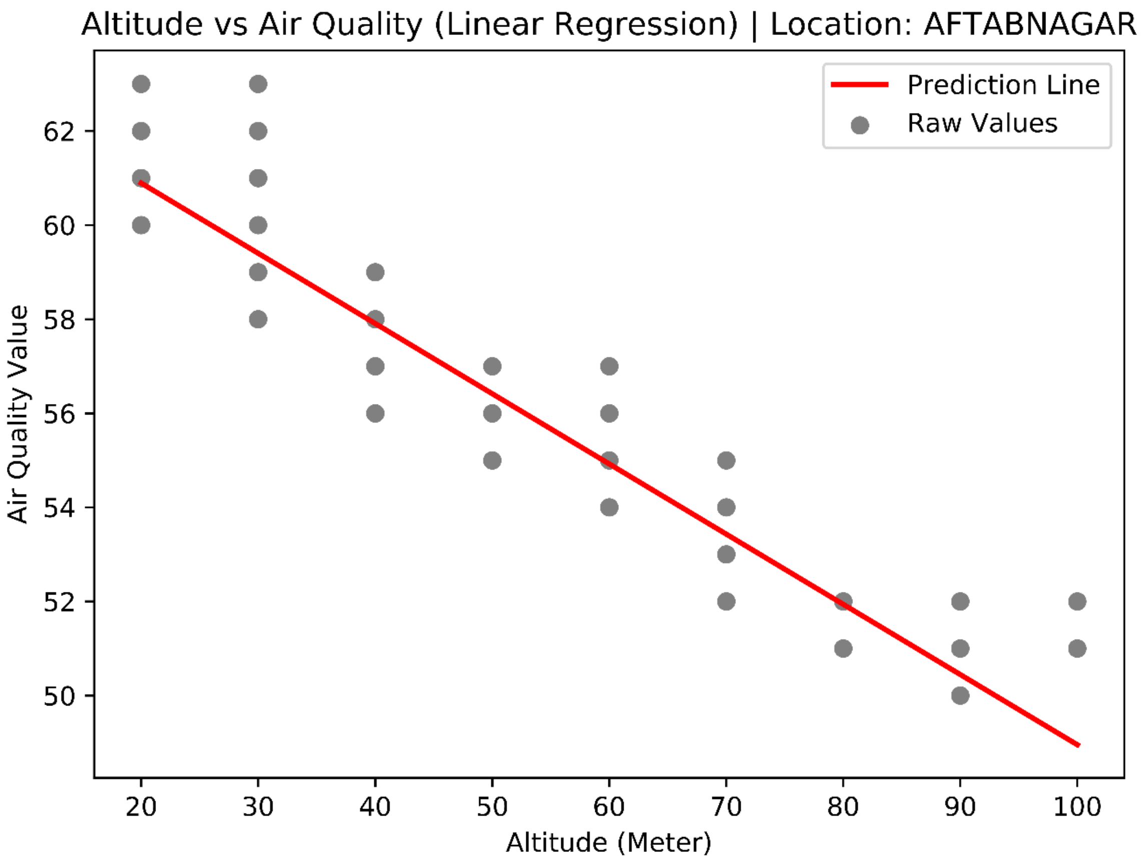

Humidity vs CO2 (Linear Regression) | Location: AFTABNAGAR
Prediction Line
Raw Values
CO2 (PPM)
58
57
56
55
54
53
52
51
50
87
88
89
90
91
92
Humidity (%)

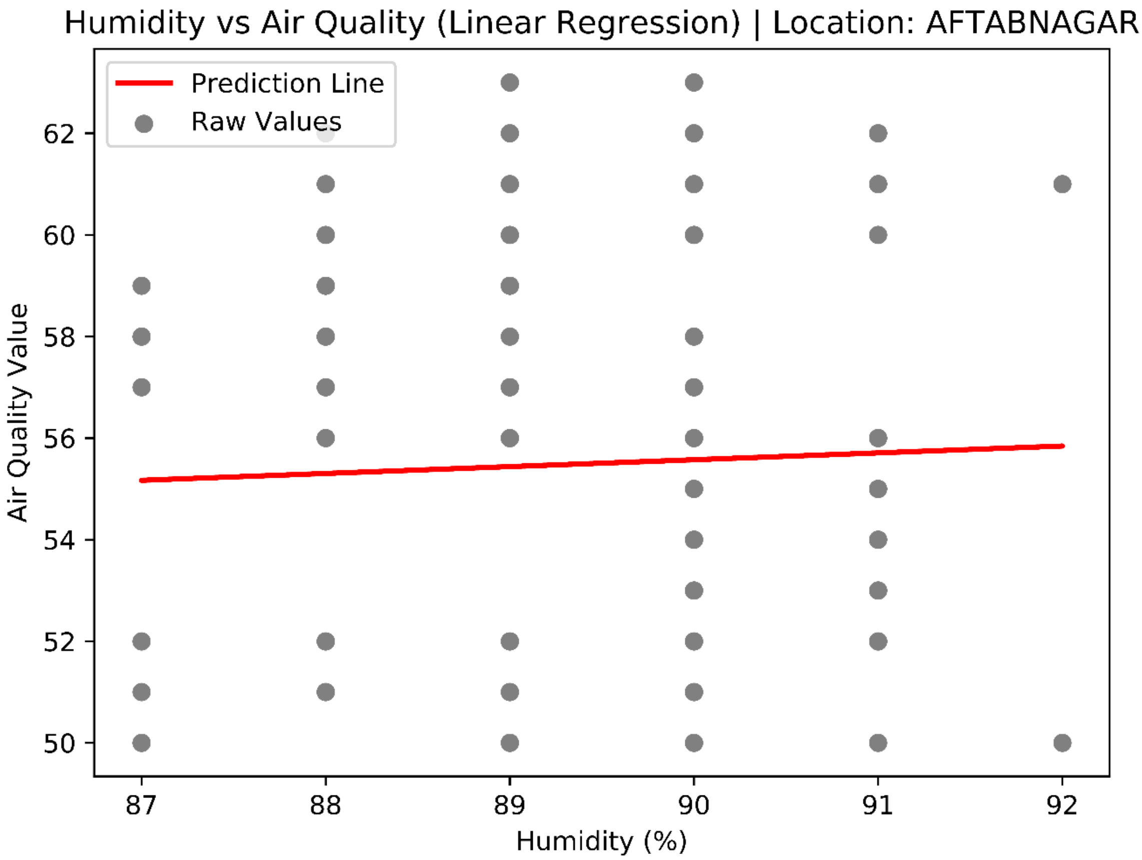

Temperature vs CO2 (Linear Regression) | Location: AFTABNAGAR
Prediction Line
Raw Values
CO2 (PPM)
58
57
56
55
54
53
52
51
50
17.2
17.4
17.6
17.8
18.0
18.2
18.4
Temperature (Celsius)

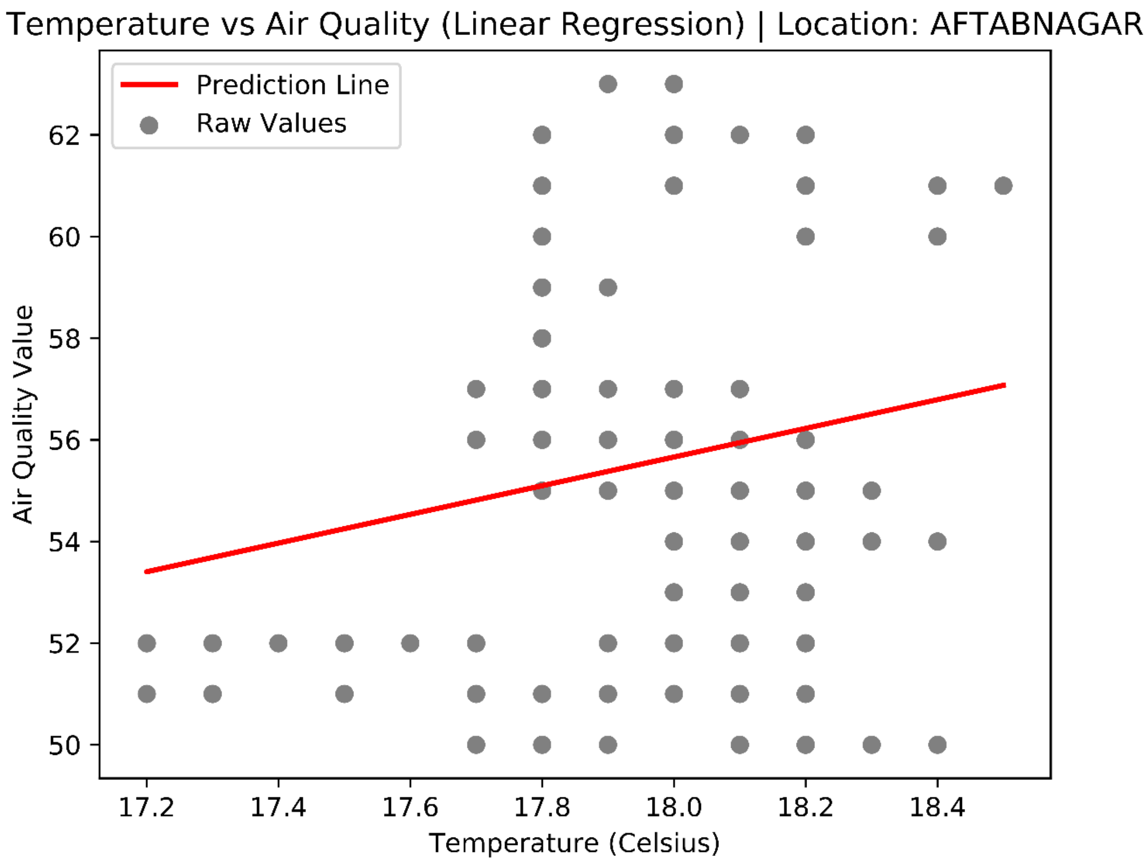

Altitude vs CO (Linear Regression) | Location: AFTABNAGAR
Prediction Line
Raw Values
CO (PPM)
4.00
3.95
3.90
3.85
3.80
3.75
20
30
40
50
60
70
80
90
100
Altitude (Meter)


Humidity vs CO (Linear Regression) | Location: AFTABNAGAR
Prediction Line
Raw Values
CO (PPM)
4.00
3.95
3.90
3.85
3.80
3.75
87
88
89
90
91
92
Humidity (%)


Temperature vs CO (Linear Regression) | Location: AFTABNAGAR
Prediction Line
Raw Values
CO (PPM)
4.00
3.95
3.90
3.85
3.80
3.75
17.2
17.4
17.6
17.8
18.0
18.2
18.4
Temperature (Celsius)


Altitude vs Air Quality (Linear Regression) | Location: AFTABNAGAR
Prediction Line
Raw Values
Air Quality Value
62
60
58
56
54
52
50
20
30
40
50
60
70
80
90
100
Altitude (Meter)


Humidity vs Air Quality (Linear Regression) | Location: AFTABNAGAR
Prediction Line
Raw Values
Air Quality Value
50
52
54
56
58
60
62
87
88
89
90
91
92
Humidity (%)


Temperature vs Air Quality (Linear Regression) | Location: AFTABNAGAR
Prediction Line
Raw Values
Air Quality Value
50
52
54
56
58
60
62
17.2
17.4
17.6
17.8
18.0
18.2
18.4
Temperature (Celsius)

5.10 Collected Data from UAV (Mirpur)

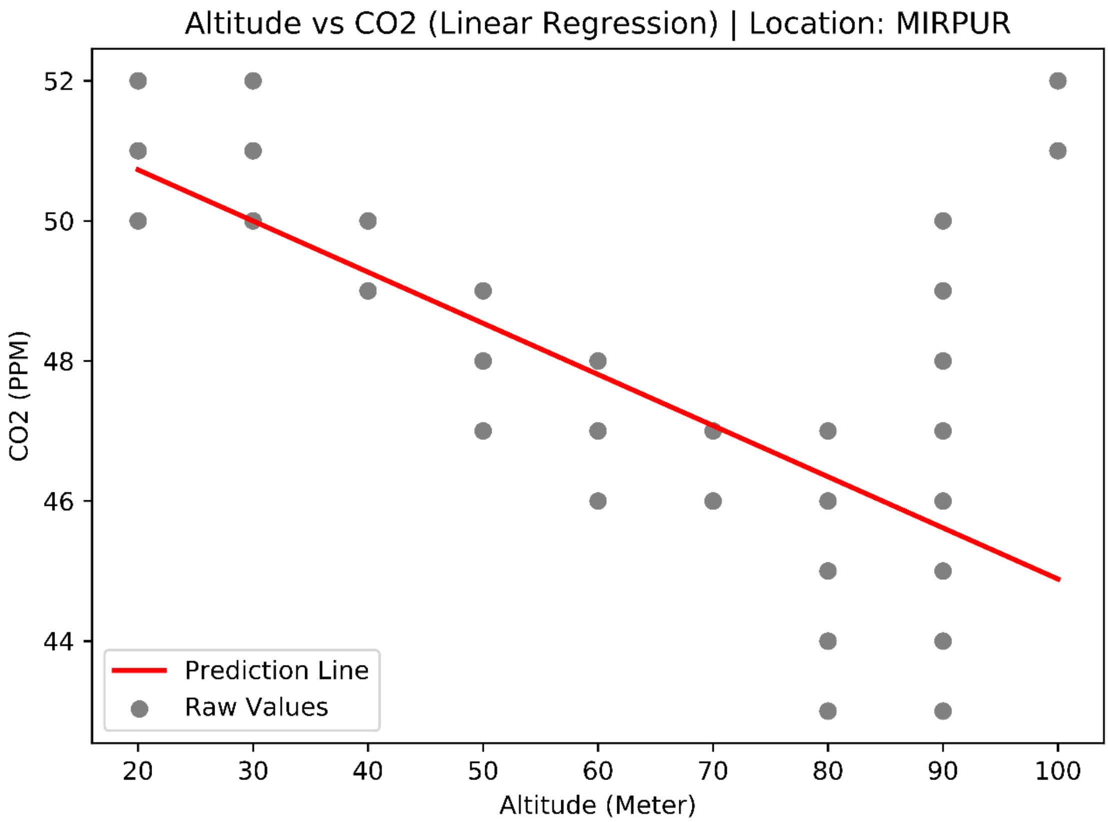
SN	Altitude (meter)	Temperature (Celsius)	Humidity (%)	CO2 (PPM)	CO (PPM)	Air Quality
1	20	18.1	90	56	3.85	62
		18.9	92	52	3.84	59
		18.8	92	51	3.84	59
		18.8	92	52	3.85	58
		18.8	92	51	3.85	58
2	30	18.2	89	52	3.85	58
		18.5	92	50	3.83	58
		18.5	92	51	3.84	58
		18.6	92	50	3.85	58
		18.5	92	50	3.86	57
3	40	17.7	90	57	3.84	56
		18.3	93	50	3.75	57
		18.2	93	49	3.74	56
		18.2	92	49	3.74	56
		18.2	92	49	3.74	56
4	50	18.1	91	55	3.85	55
		18.5	91	47	3.72	55

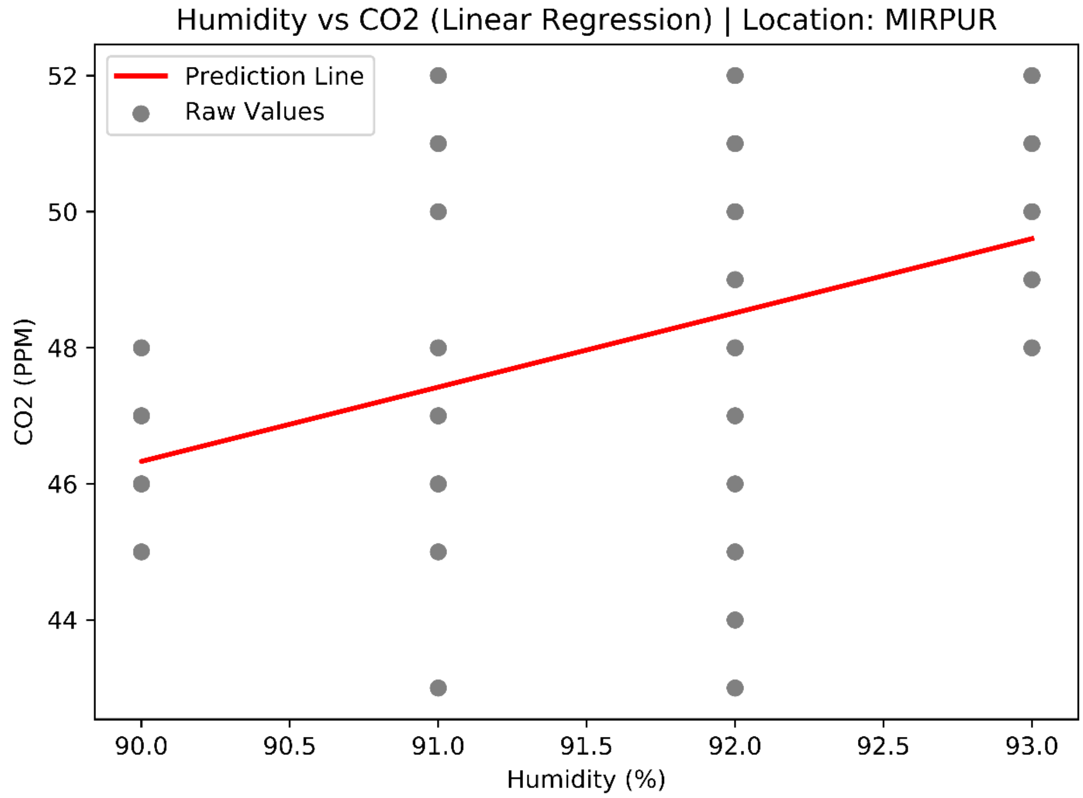
		18.5	91	48	3.72	55
		18.6	91	48	3.72	55
		18.6	91	47	3.72	54
5	60	18.4	90	53	3.82	54
		18.3	90	47	3.74	53
		18.4	91	47	3.75	54
		18.4	91	47	3.74	55
		18.3	91	46	3.73	54
6	70	18.1	90	53	3.81	53
		18.1	91	46	3.77	54
		18	91	46	3.77	54
		18.1	91	46	3.81	54
		18	90	46	3.81	53
7	80	17.3	89	51	3.84	51
		18.3	92	43	3.85	52
		18.3	92	44	3.86	52
		18.2	92	44	3.85	52
		18.4	92	44	3.84	52
8	90	17.7	87	50	4	17.7
		18.4	92	48	4.36	56

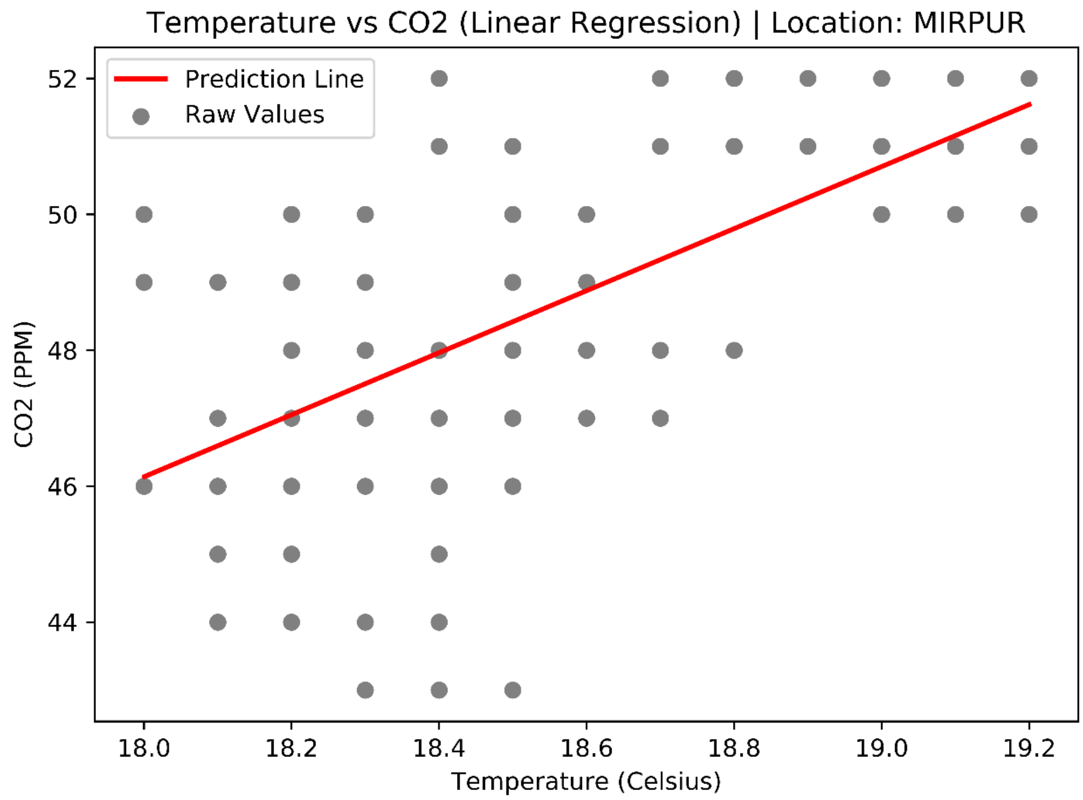
		18.4	92	48	4.39	56
		18.6	92	48	4.43	57
		18.6	93	48	4.46	57
9	100	17.40	92.00	43	3.98	51
		18.5	93	49	4.47	56
		18.5	93	49	4.47	57
		18.6	93	49	4.48	57
		18.5	93	50	4.48	56
10	110	17.60	92.00	47	4.19	55
		18.4	93	51	4.74	56
		18.4	93	52	4.74	57
		18.5	93	51	4.77	57
		18.4	93	52	4.77	56

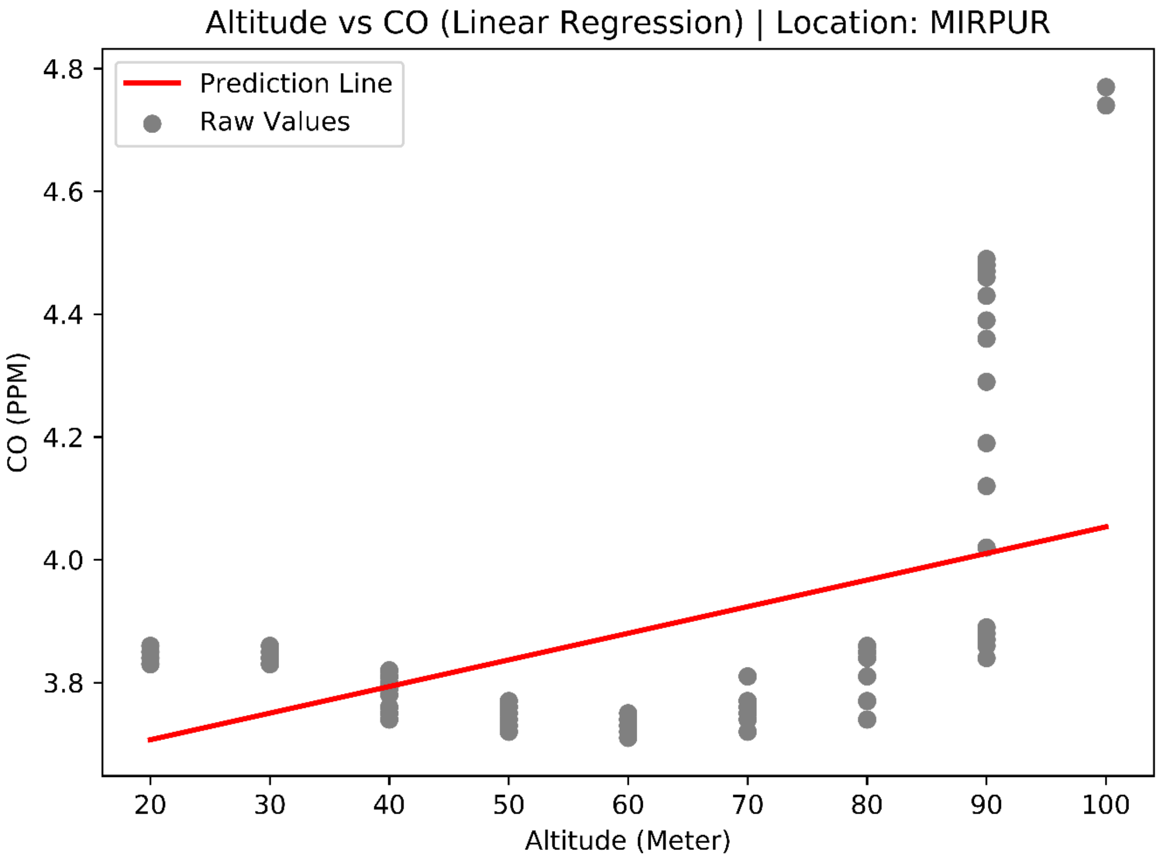
5.11 Best Fit Linear Regression Model for Mirpur

Here is observation of best fit linear model for Mirpur area which includes (CO_2, CO, air quality) vs. altitude, (CO_2, CO, air quality) vs. Humidity and (CO_2, CO, air quality) vs. temperature.

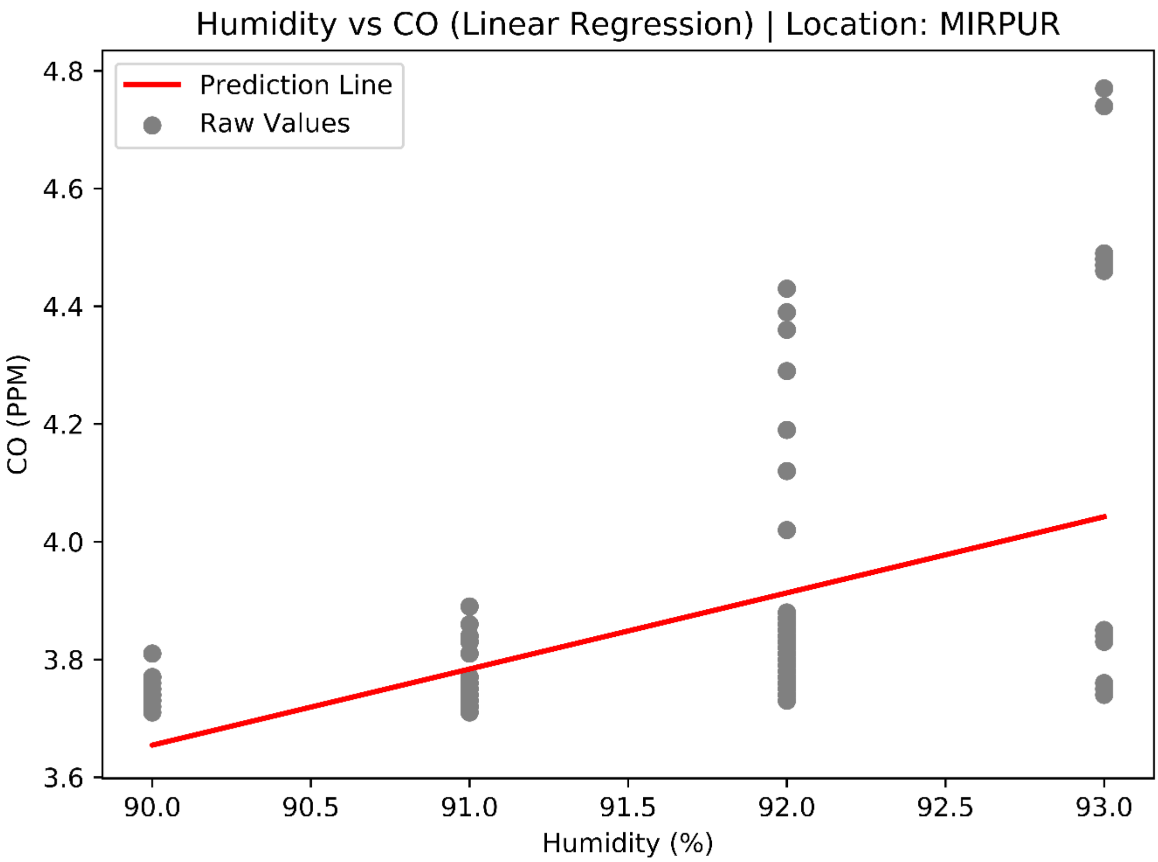



Humidity vs CO2 (Linear Regression) | Location: MIRPUR
Prediction Line
Raw Values
52
50
48
46
44
CO2 (PPM)
90.0
90.5
91.0
91.5
92.0
92.5
93.0
Humidity (%)

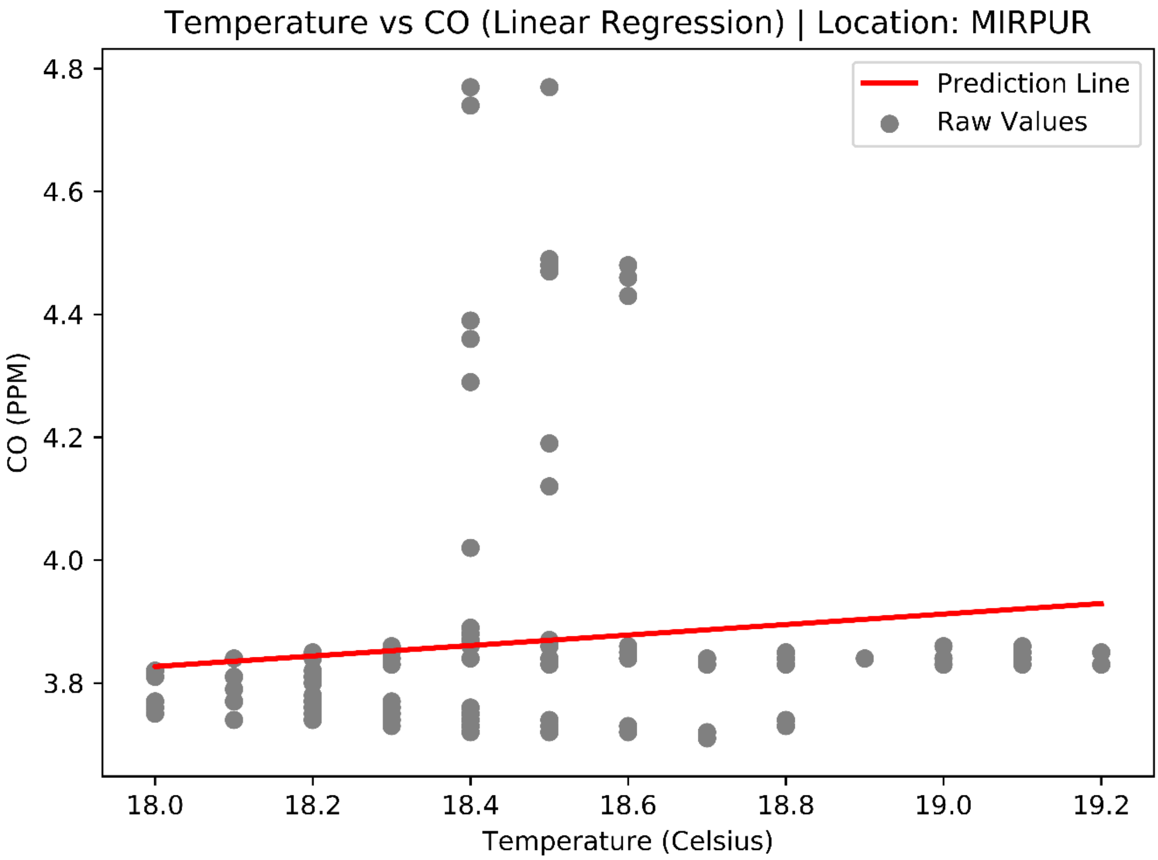

Temperature vs CO2 (Linear Regression) | Location: MIRPUR
Prediction Line
Raw Values
52
50
48
46
44
CO2 (PPM)
18.0
18.2
18.4
18.6
18.8
19.0
19.2
Temperature (Celsius)

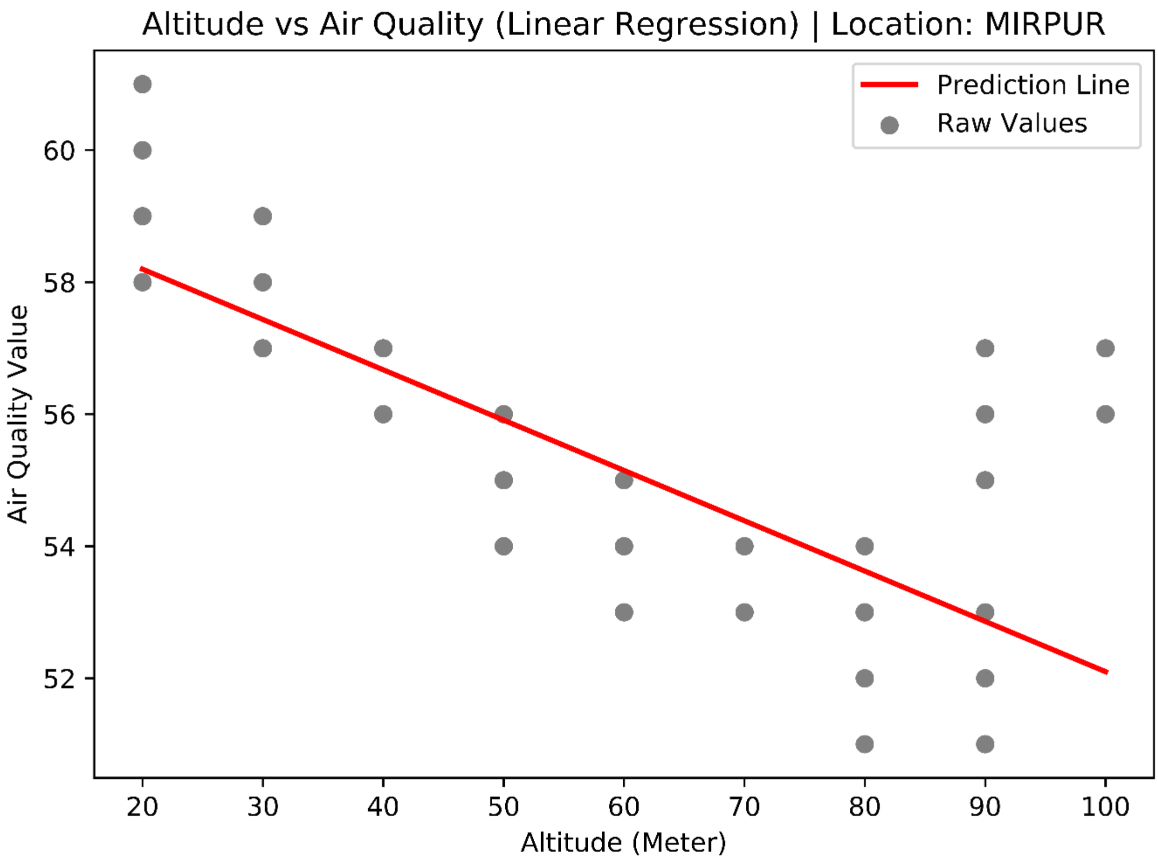


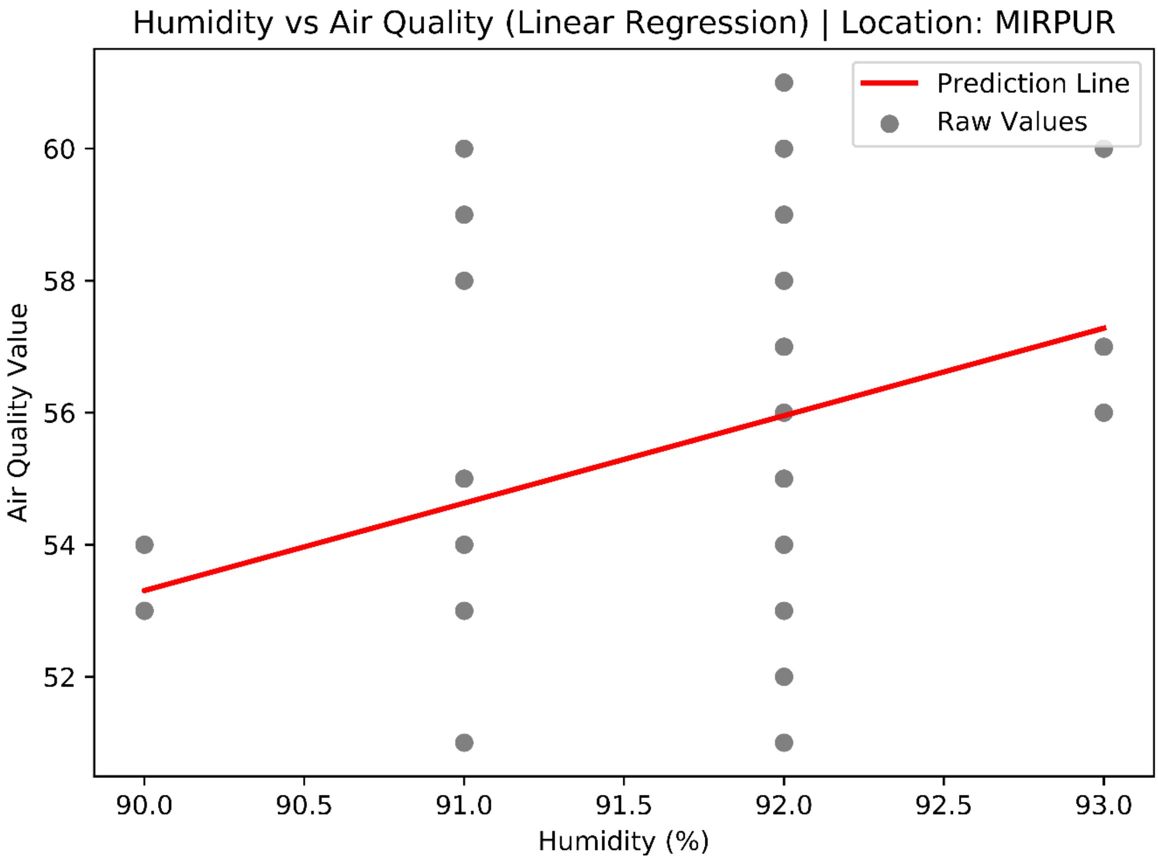
Altitude vs CO (Linear Regression) | Location: MIRPUR
Prediction Line
Raw Values
CO (PPM)
4.8
4.6
4.4
4.2
4.0
3.8
20
30
40
50
60
70
80
90
100
Altitude (Meter)

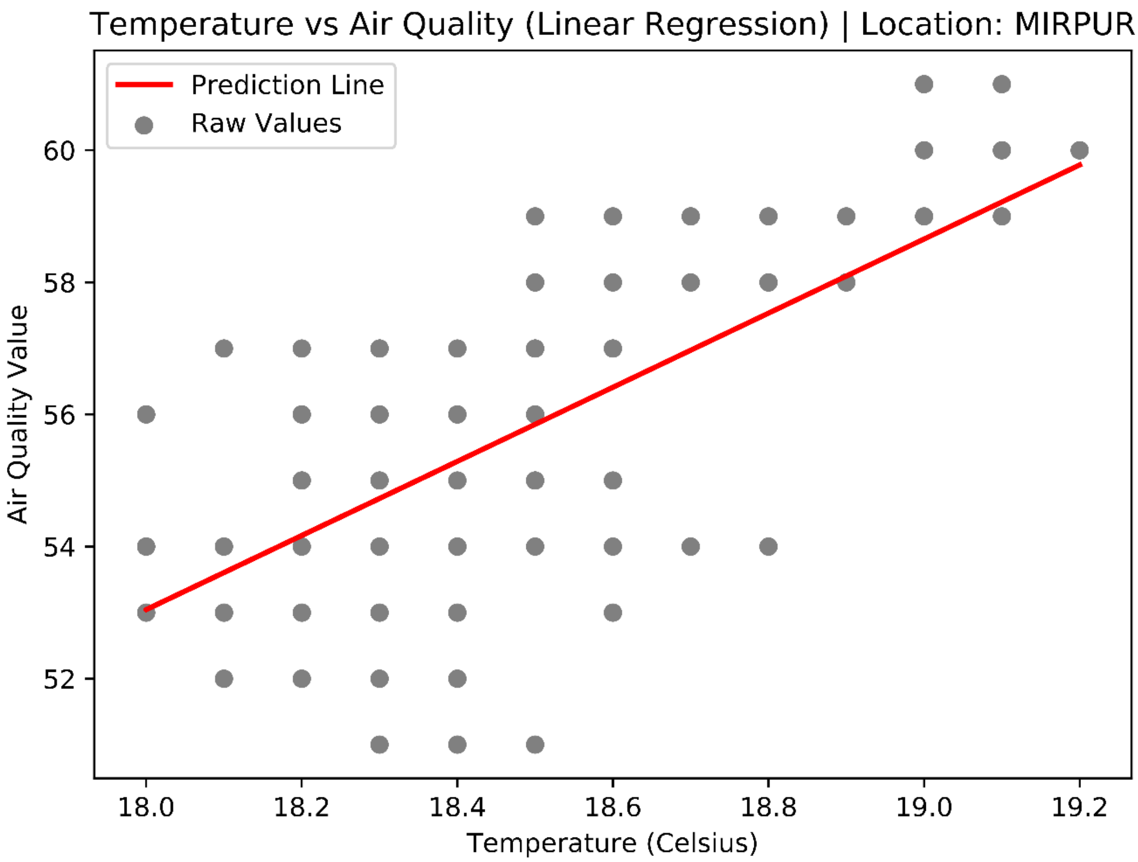


Humidity vs CO (Linear Regression) | Location: MIRPUR
Prediction Line
Raw Values
CO (PPM)
4.8
4.6
4.4
4.2
4.0
3.8
3.6
90.0
90.5
91.0
91.5
92.0
92.5
93.0
Humidity (%)


Temperature vs CO (Linear Regression) | Location: MIRPUR
Prediction Line
Raw Values
CO (PPM)
4.8
4.6
4.4
4.2
4.0
3.8
18.0
18.2
18.4
18.6
18.8
19.0
19.2
Temperature (Celsius)


Altitude vs Air Quality (Linear Regression) | Location: MIRPUR
Prediction Line
Raw Values
Air Quality Value
60
58
56
54
52
20
30
40
50
60
70
80
90
100
Altitude (Meter)


Humidity vs Air Quality (Linear Regression) | Location: MIRPUR
Prediction Line
Raw Values
Air Quality Value
60
58
56
54
52
90.0
90.5
91.0
91.5
92.0
92.5
93.0
Humidity (%)


Temperature vs Air Quality (Linear Regression) | Location: MIRPUR
Prediction Line
Raw Values
Air Quality Value
60
58
56
54
52
18.0
18.2
18.4
18.6
18.8
19.0
19.2
Temperature (Celsius)

5.12 Result Analysis

In this procedure we have performed three different functions which includes altitude, temperature and humidity. The analysis includes CO_2, CO and air quality for the comparison. In Uttara it is observed that the relationship between CO_2 and altitude is linearly decreasing. Also, for the range of 80 to 90 meters we get the best fit. Again, for CO it increases with height. In this observation we get the best fit in 90-meter altitude. For air quality we can observe similar characteristics. When we compare the different functions for humidity a similar curve is observed which linearly deceases. For temperature there are discrete values obtained. In conclusion it can be added although there are random values in the graphs but for lower level of air around us pollution is heavy. As we move upward, we observe less pollution. All the random values from the fitted curve observed are nearly identical as a fixed function and also behaves accurately for a fixed range of the parameters.

Chapter 6

Future work & Conclusion

With the help of the aerial vehicle and the ground station all the corresponding data will be collected. The data from DHT11, MQ2, MQ7 will be stored in excel. For future work, using MATLAB platform it is possible to make future predictions (regression model). In regression model a measurement of strength is analyzed. For that two set of data (one independent, one dependent) are needed. As MATLAB can import excel sheets and with model fitting and regression model this input can give the future outputs with corresponding graphs. To do these two variables are needed and here temperature and the gas percentage can be fitted there. Using plotting command from the MATLAB it should give an output as graphs of different orders. Again, from tools option best fit can be selected and the equation for the fit. So, with the help of our UAV all these data can be collected and by using the MATLAB platform it should be ready to analyses different data. The idea of future work can be benefited as the vehicle can store data of area and send them to the server and with the help of the data collected it can also predict the future data.

In this project the focus was to collect the data from the environment about the ratio and proportion of the gases and other element like humidity temperature. And afterwards create a regression model to predict the future condition of that experimental place. The whole system starting from data collection to data receiving from the other end and analyzing the data - worked properly. The minor error of this system has been solved. And test runs were successfully performed for several of times. So, it can be hoped that the system would be pretty much helpful to resolve the environmental issues regarding greenhouse problems. And in future by adding other sensors it can also be used in advanced used to protect the environment. The whole idea of this project will help a lot to design a better version of this AUV in near future.

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