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Development of IOT Device for Sensing Weather and Environmental Pollutants

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Pollutants emitted into the atmosphere, such as ozone, which raises temperature, contributes to climate change. This may have inverse effect on the local air quality. However, other Particulate Matter (PM) components can heat or cool the temperature. Weather and environmental pollution can cause headaches, heart disease, respiratory problems, acid rain, fever, and other symptoms that are harmful to both people and the environment. This research center on development of smart sensors to monitor our environment's exposure to weather and environmental contaminants. This was made possible by developing an interface between data collection and monitoring equipment that interfaced with a website and analysis software. The online portal records and analyzes the measured data from the monitoring device in accordance with the WHO (World Health Organization) standard. It also compares the measured data from various locations. The main microcontroller in this work is an Arduino UNO which helps in data collection; and the CoolTerm application which helps exchange data with hardware connected to serial ports with the microcontroller. The system monitors environmental changes such as temperature and precipitation. The data is displayed as graphical statistics on the web site's design in the form of web portal information.

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Offices on the Federal Polytechnic Ile Oluji campus, in addition to the production powerhouse, are used to test the equipment. Each dataset was generated in three minutes and compared to the WHO standard. People who live near generators, according to the findings, face a greater risk to their health.

Keywords: Arduino UNO; microcontroller; cool term application; web portal.

1. INTRODUCTION

Pollution occurs when the earth/atmosphere system's physical and biological components are contaminated to the point where normal environmental processes are disrupted. Industrial and vehicular emissions, as well as increased levels of hazardous gases such as CO and particulates, pollute the air. Industries, urbanization, population growth, and automobile usage all contribute to increased environmental pollution [1-5]. Thus, real-time air quality monitoring is required to make timely decisions. Car and generator smoke, for example, contribute significantly to current air pollution. There are numerous sensors that can detect air quality; therefore, a decent metric is needed to expose the intensity level of air pollution, whether low, medium, or high. The corresponding values can be used to make a different choice. Sensors can now communicate with the cloud via IoT, storing data in a MySQL database accessible from any computer with internet access. With the CoolTerm application, data is collected from an Arduino serial monitor by clicking on its COM port. Weather monitoring is critical for human survival, so data collection on temporal dynamics is vital. This Internet of Things project uses an Arduino UNO, CoolTerm software, and various weather sensors (DHT-11, MQ-135, sound sensor, etc.) to monitor the weather. This weather station is powered by the Internet of Things (the internet of things). It has environmental sensors that collect and distribute polluted gases in a specific location and report them in real time on the cloud. The result is viewed live on the weather station's website or sent as an SMS to a specific user or individual. Data can be accessed remotely using Internet-enabled devices. Sensors collect and transmit real-time weather data to a remote web server via the internet. The weather parameters are uploaded to the cloud for real-time weather reporting and data visualization.

2. LITERATURE REVIEW

Karthigaeni and Nithyalakshmi [1] built a Wireless Weather Monitoring System using Blynk Server. This project describes a wireless internet of things weather monitoring system (IOT). Weather monitoring is used in both agriculture and industry. Temperature, soil moisture, humidity, and vibration are the four basic parameters. Users can use their smartphones to access any internet-based information.

A sensor-powered Smart Weather Station by Dorevi and Dankovi. The system uses internet of things technology to record measurements and allows users to access them from anywhere. The system consists of embedded sensors, a PIC microcontroller serving as the system's core and server, and wireless internet access via a GSM module using the General Packet Radio Service (GPRS) communication protocol.

Firdous and Samantha (2020) powered a smart weather station for microclimate monitoring. The study shows the developed device can be installed and monitored anywhere remotely. The developed device collects and transmit data at fixed intervals.

Nivedan and Kannusamy (2019) developed weather monitoring system using IoT with Arduino Ethernet shield. The developed device monitored the weather changes and stores the data using various sensors.

Musa and Bashir (2018) created a microcontroller-based mobile weather station. Temperature, pressure, relative humidity, solar radiation, and wind speed are all measured and displayed by a weather station. The goal is to develop a remote-access mobile weather monitoring system. Each of the following sensors were used: an Anemometer for wind speed, a DHT11 for temperature and relative humidity, an MPX5100AP for pressure, an LDR for light intensity, and a microcontroller (MMC). A weather monitoring system was set up to record five weather parameters on a memory card.

Kashyap et al (2020) developed a smart weather techniques using machine learning. The datasets undergo data-preprocessing task and subjected to multi-target regression and recurrent neural networks to predict three weather conditions.

2.1 Design Analysis

Diagram of the system in Fig. 1 the atmega 328p microcontroller is connected to the sensors via the arduino uno's digital and analogue pins. Sensor data is sent to the microcontroller, which processes it and displays the results on the serial monitor of the arduino board. The lcd screen displayed the sensor data on the display device. The computer system powers the lcd and the rest of the system. Dht-11, mq-135, sound, and uv light sensors reading data from atmel atmega328, which is then entered into the mysql database by php routines. The atmega328 is used.

2.2 Circuit Diagram

The circuit schematic was created on a Windows 10 PC using Proteus professional software. Fig. 2 shows a Proteus schematic and diagram. The Arduino microcontroller collects data from sensors connected to its pins. Sensors that require 3.3V or use a 3.3V pin out from the board to accept 5V from Arduino Uno are not connected to the microcontroller. The microcontroller is powered by the computer system. These sensors have three terminals, so they work with either the 3.3v or 5v Arduino boards. To send data, the Arduino's GND pin connects to the board's ground terminal, and the Data pin connects to a digital or analog pin. The UV light and UV sensor are connected to Arduino A2. The DHT-11, MQ135 and sound sensor are connected to Arduino digital pin 2. A 3.3 volt battery powers the DHT-11. MQ1235, the sound sensor voltage, and the UV light all use 5 volts. The LCD is powered by a 5 volt battery. Sensors on a breadboard require 5 volts.

2.3 Flowchart Algorithm

It shows the operational flow of communication and data transfer between the Arduino Uno and the sensors, i.e. how data is transmitted from the sensors to the webpage, in Fig. 3. The system design flowchart

Step 1: Start
Step 2: Weather sensors sense the atmospheric condition in the environment
Step 3: Microcontroller check the sensor codes and libraries
Step 4: If the libraries and codes are correct, data is displayed on the serial monitor and LCD
Step 5: CoolTerm application convert the data displayed on the serial monitor into a text file by Connecting it with the COM port
Step 6: Converted text file will be called using PHP and insert the content into the database.

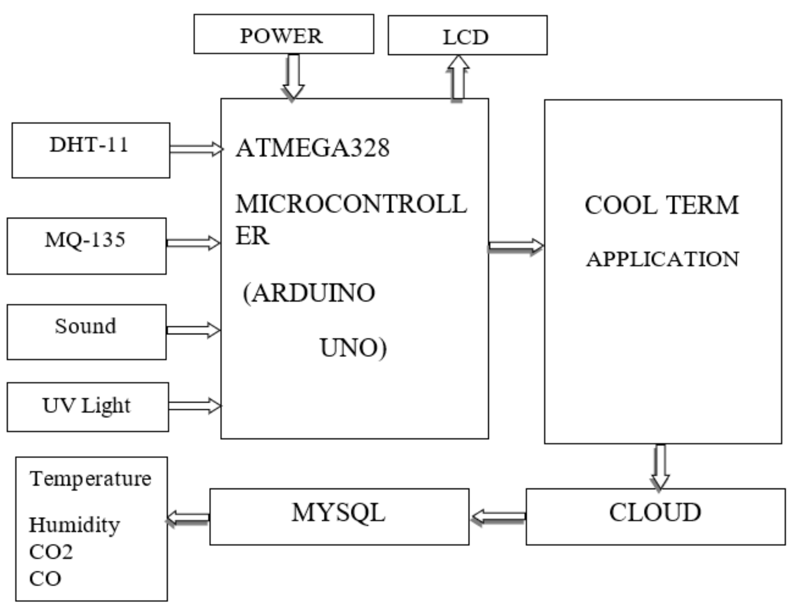

Fig. 1. The system block diagram

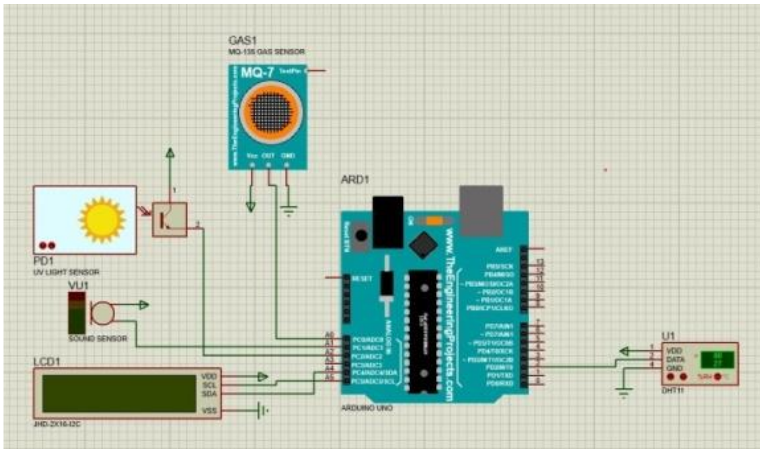

Fig. 2. Proteus circuit diagram design

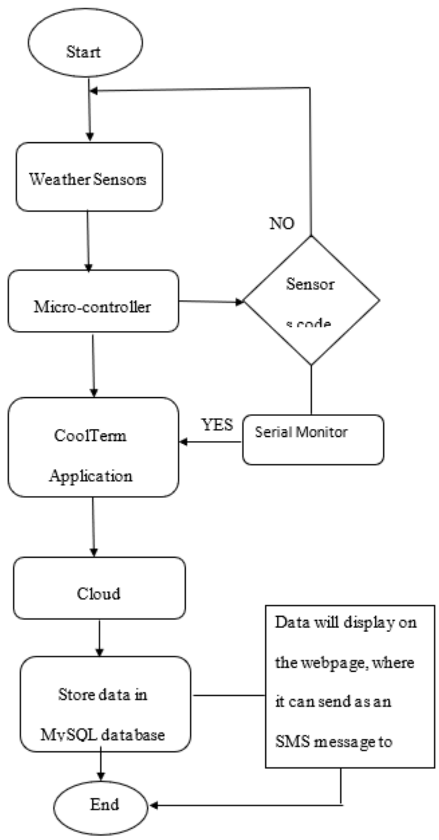

Fig. 3. Flowchart of the System

2.4 Webpage Development

It was made with the sublime text editor, bootstrap, HTML, CSS, and PHP. Figs. 4–8 show the website interface. A web server connection is made to the recorded files folder, and then the measured data is shown on the webpage. The graph, bar chart, and pie chart can be downloaded as PDFs. Users can receive data via SMS from the admin panel. Using a secure login, visitors can view daily instrument readings on the website.

Fig. 4. Front page of weather website with daily results

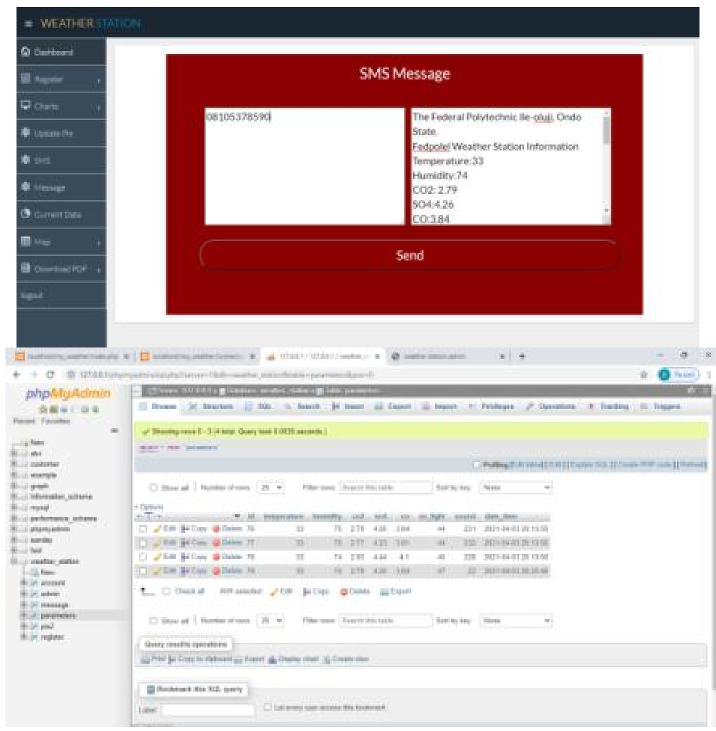

Fig. 5. SMS page and database weather data

3. RESULTS AND DISCUSSION

3.1 Hardware Packaging

Figure 6 depicts the developed hardware setup. The Arduino Uno is connected to the components, which are then enclosed in an adaptable box to keep them safe from outside disturbance.

3.2 Testing and Result

The developed device was tested at several locations, including the academic take-off of the Federal Polytechnic of Ile Oluji Ondo State, the permanent Federal Polytechnic site, the School of Engineering building within the same institution, and the educational environment. Climate change and pollution are assessed by comparing data collected from various locations to WHO guidelines. Table 1 displays the WHO standard, dangerous values, and items that conform to those values.

3.3 SMS Message to Mobile Phone and Graphical Results

The message is sent to a mobile phone that has a registered SIM. Once the button is clicked on the webpage, the content of the message will be delivered to the phone number entered in the text box.

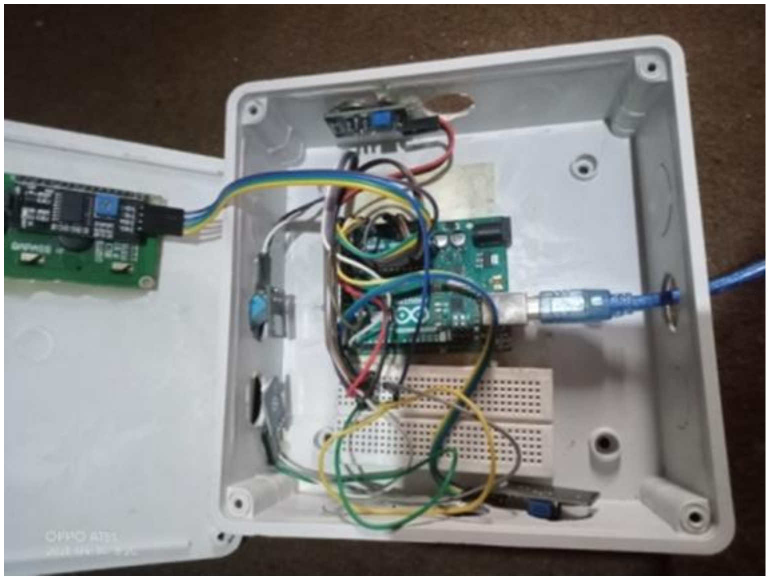

Fig. 6. Components arrangement in the Adaptable box

3.3.1 Generated Values for 3 minutes at different locations on the campus

```
COM9

Calibrating please wait...........  done!.
THE SENSORS TAKE READINGS EVERY 3mins


Temperature|Humidity|CO2|SO4|CO|UV light|S
31.70;70.00;2.49;3.86;3.28;90.00;424.00
31.70;70.00;2.53;3.92;3.36;91.00;425.00
31.70;70.00;2.57;3.96;3.42;90.00;425.00
31.80;70.00;2.61;4.02;3.51;92.00;426.00
31.80;70.00;2.61;4.02;3.51;89.00;426.00
31.80;70.00;2.63;4.04;3.54;86.00;426.00
31.90;70.00;2.63;4.04;3.54;91.00;426.00
31.90;70.00;2.68;4.11;3.63;91.00;427.00
31.90;71.00;2.65;4.07;3.57;91.00;429.00
31.90;71.00;2.55;3.94;3.39;86.00;426.00
31.90;72.00;2.50;3.88;3.31;127.00;425.00
31.90;71.00;2.50;3.88;3.31;113.00;425.00
32.00;71.00;2.55;3.94;3.39;111.00;426.00
32.00;70.00;2.55;3.94;3.39;143.00;425.00
32.10;70.00;2.57;3.96;3.42;134.00;425.00
32.10;69.00;2.57;3.96;3.42;134.00;425.00
32.20;69.00;2.55;3.94;3.39;129.00;425.00
32.30;69.00;2.53;3.92;3.36;123.00;425.00
32.30;69.00;2.53;3.92;3.36;113.00;425.00
32.30;69.00;2.58;3.98;3.45;109.00;425.00
32.30;69.00;2.60;4.00;3.48;115.00;426.00
32.30;68.00;2.57;3.96;3.42;116.00;425.00
32.30;68.00;2.57;3.96;3.42;114.00;424.00
32.30;68.00;2.57;3.96;3.42;114.00;424.00
32.30;68.00;2.57;3.96;3.42;114.00;426.00
32.30;68.00;2.57;3.96;3.42;113.00;424.00
```

```
COM9

Calibrating please wait...........  done!.
THE SENSORS TAKE READINGS EVERY 3mins


Temperature|Humidity|CO2|SO4|CO|UV light|Sou
30.50;73.00;2.51;3.89;3.32;103.00;441.00
30.40;73.00;2.50;3.87;3.30;104.00;441.00
30.50;73.00;2.48;3.85;3.27;98.00;439.00
30.50;73.00;2.44;3.79;3.19;97.00;437.00
30.50;73.00;2.42;3.77;3.16;95.00;436.00
30.50;72.00;2.44;3.79;3.19;94.00;436.00
30.50;72.00;2.48;3.85;3.27;94.00;437.00
30.50;72.00;2.51;3.89;3.32;94.00;438.00
30.50;72.00;2.53;3.91;3.35;94.00;439.00
30.50;72.00;2.53;3.91;3.35;93.00;439.00
30.50;72.00;2.56;3.95;3.41;93.00;439.00
30.50;72.00;2.54;3.93;3.38;93.00;439.00
30.60;73.00;2.56;3.95;3.41;93.00;439.00
30.50;73.00;2.56;3.95;3.41;99.00;440.00
30.60;73.00;2.58;3.97;3.44;167.00;439.00
30.60;73.00;2.58;3.97;3.44;172.00;440.00
30.80;72.00;2.58;3.97;3.44;105.00;439.00
30.90;72.00;2.59;3.99;3.47;95.00;440.00
31.10;73.00;2.58;3.97;3.44;169.00;438.00
31.30;72.00;2.61;4.01;3.50;180.00;439.00
31.40;72.00;2.64;4.06;3.56;101.00;439.00
31.60;72.00;2.66;4.08;3.59;99.00;440.00
31.70;71.00;2.67;4.10;3.62;99.00;441.00
```

```
COM9

Calibrating please wait...........  done!.
THE SENSORS TAKE READINGS EVERY 3mins


Temperature|Humidity|CO2|SO4|CO|UV light|Sound
32.20;68.00;2.53;3.91;3.35;89.00;422.00
31.90;69.00;2.60;4.01;3.49;89.00;424.00
31.80;69.00;2.69;4.12;3.64;89.00;426.00
31.70;69.00;2.72;4.16;3.71;88.00;426.00
31.70;69.00;2.77;4.23;3.80;88.00;425.00
31.60;70.00;2.77;4.23;3.80;87.00;428.00
31.50;70.00;2.79;4.25;3.83;87.00;426.00
31.50;70.00;2.77;4.23;3.80;87.00;428.00
31.40;71.00;2.75;4.21;3.77;87.00;427.00
31.40;71.00;2.77;4.23;3.80;87.00;427.00
31.40;71.00;2.74;4.18;3.74;85.00;425.00
31.30;71.00;2.72;4.16;3.71;84.00;423.00
31.20;71.00;2.57;3.97;3.43;84.00;422.00
31.10;71.00;2.59;3.99;3.46;83.00;421.00
31.10;71.00;2.56;3.95;3.41;82.00;421.00
31.00;72.00;2.54;3.93;3.38;81.00;418.00
30.90;71.00;2.54;3.93;3.38;81.00;420.00
30.90;71.00;2.54;3.93;3.38;80.00;417.00
30.80;71.00;2.54;3.93;3.38;80.00;420.00
30.70;72.00;2.53;3.91;3.35;80.00;419.00
30.60;72.00;2.54;3.93;3.38;82.00;420.00
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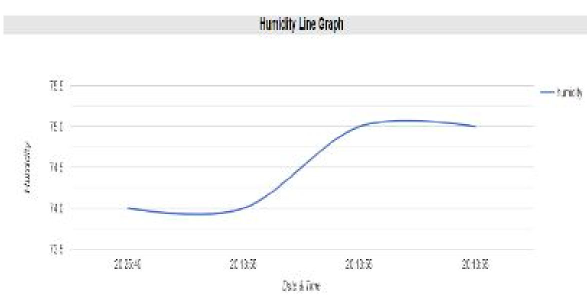
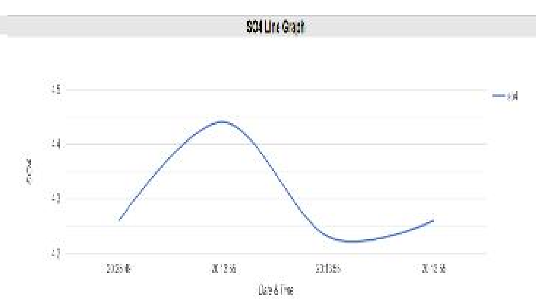
Fig. 7. Point of Generator data at Academic take off-site, School of Engineering and School Environment data





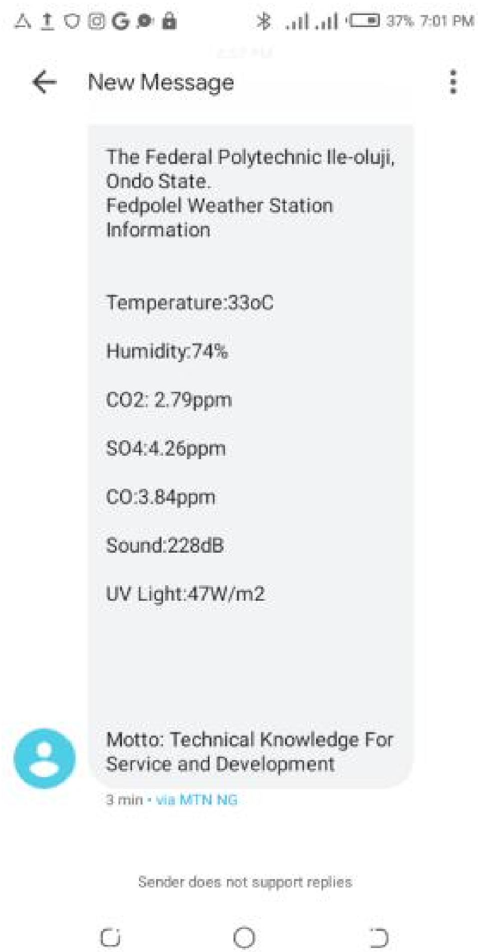


Fig. 8. SMS message sent to mobile phone; Humidity and SO4 daily results

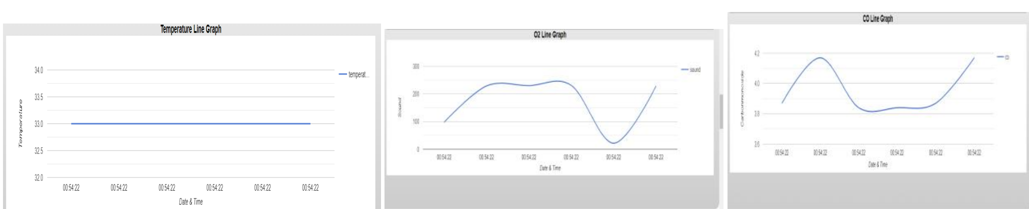


Fig. 9. Temperature, Sound and CO daily results

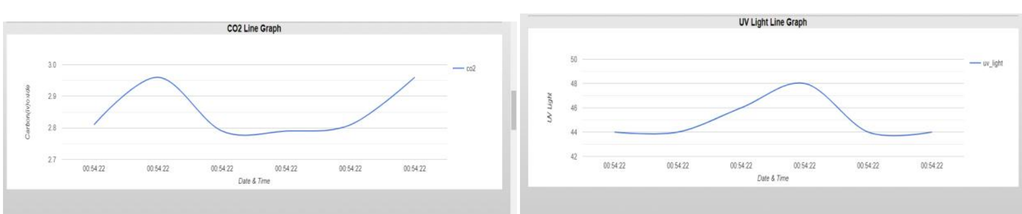


Fig. 10. CO_2 and UV Light daily results

Table 1. W.H.O Standard and their harmful values

PARAMETERS	WHO STANDARD	HARMFUL VALUE	EFFECTS
Temperature	36.5°C - 37.2°C	40°C	Heat cramps, Fever, Feeling and death
Humidity	30% - 60%	61%	Overheating, Uncomfortable etc.
Carbon(iv)oxide	250ppm – 400ppm	500ppm and above	Headache, Dizziness, Difficulty in breathing.
Sulfide	200ppm – 250ppm	250ppm above	Acidic rain
Carbon monoxide	50ppm – 100ppm	150ppm above	Reduction in the flow of blood in the body, Headache Headache.
Sound	30dB – 69Db	70dB above	Difficulty in hearing, High blood pressure, Heart diseases, Lack of sleep.
UV Light	0 – 5	8	Ageing of the skin, Eye problems and Skin cancer.

Table 2. Highest and Lowest Point of Data Measured at 3 Locations

Parameters	Location 1		Location 2		Location 3	
	Highest point	Lowest point	Highest point	Lowest point	Highest point	Lowest point
Temperature	30.70	30.40	32.30	31.70	32.20	30.60
Humidity	73.00	71.00	72.00	68.00	72.00	68.00
Carbon(iv)oxide	2.67	2.42	68.00	49.00	2.79	2.53
Sulfide	4.10	3.77	4.11	3.86	4.25	3.91
Carbon monoxide	3.62	3.16	3.63	3.28	3.83	3.35
Sound	4.41	4.36	429.00	424.00	428.00	417.00
UV Light	104.00	93.00	143.00	86.00	89.00	80.00

Table 3. Comparison of Lowest Point Data with the W.H.O Standard

Parameters	Who standard	Harmful	Lowest point			Effects
			Location 1	Location 2	Location 3	
Temperature	36.5°C - 37.2°C	40°C	30.40	31.70	30.60	None
Humidity	30% - 60%	61%	71.00	68.00	68.00	Uncomfortable
Carbon(iv)oxide	250ppm – 400ppm	500ppm and above	2.42	49.00	2.53	None
Sulfide	200ppm – 250ppm	250ppm	3.77	3.86	3.91	None
Carbon monoxide	50ppm – 100ppm	150ppm	3.16	3.28	3.35	None
Sound	30dB – 69Db	70dB above	4.36	424.00	417.00	None
UV Light	0 – 5	8	93.00	86.00	80.00	None

Table 4. Comparison of Highest Point Data with the W.H.O Standard

Parameters	Who standard	Harmful	Highest point			Effects
			Location 1	Location 2	Location 3	
Temperature	36.5°C - 37.2°C	40°C	30.70	32.30	32.20	None
Humidity	30% - 60%	61%	73.00	72.00	72.00	Uncomfortable
Carbon(iv)oxide	250ppm – 400ppm	500ppm and above	2.67	68.00	2.79	None
Sulfide	200ppm – 250ppm	250ppm above	4.10	4.11	4.25	None
Carbon monoxide	50ppm – 100ppm	150ppm above	3.62	3.63	3.83	None
Sound	30dB – 69Db	70dB above	4.41	429.00	428.00	None
UV Light	0 – 5	8	104.00	143.00	89.00	None

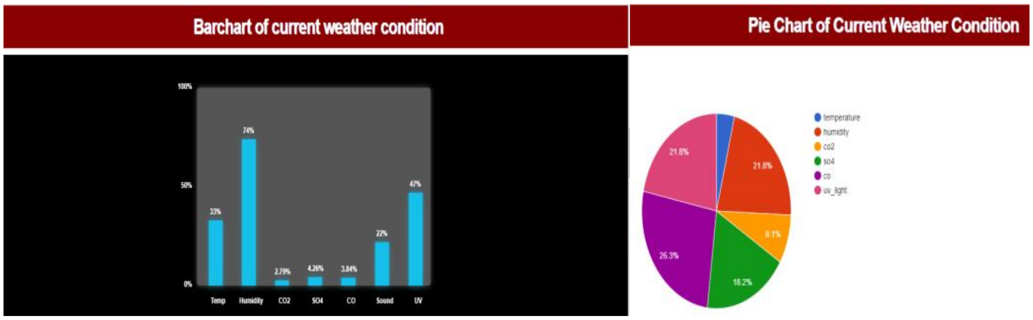


Fig. 11. Bar chart and Pie chart daily results

4. DISCUSSION

Many weather stations simply measure air pressure and display the results on an LCD screen. Data can be sent to mobile phones as SMS messages or stored in the BLYNK program, but not both at the same time. This study may send an SMS message to users who have registered their phone numbers. To obtain sensor readings remotely, graphs, bar charts, and pie charts can be used in the webpage design. Users can conduct location-based searches using the embedded map on the webpage.

5. CONCLUSION

The data obtained at the power generating section of the institution point as compared to the data collected in offices and the institution environment, the observed data differs from the WHO norm. It demonstrates that environmental toxins affect weather conditions, their spread pace is slowed down. A visual representation of the outcome can be found in table 1. Real-time data and graphical analysis of the sensed data are available on the cloud. According to the results of this experiment, implanting the device in humans can help save lives. Users can obtain the measured data from a developed system in a specific location using internet-connected devices such as cellphones, computers, and so on. A message can be sent to the registered user's mobile phone number, as shown in Fig. 9.

6. RECOMMENDATIONS

As a result, if the device is installed in a school or community, it will aid in the monitoring of weather parameters like temperature and humidity, as well as air pollutants, by informing people about weather conditions. Data can also be saved and analyzed later. If humans make good use of the data provided by the system, the developed device can aid in the reduction of pollution and the pursuit of a healthy lifestyle. This revealed that there is still significant room for future improvement of the developed device, such as the need for additional weather sensors to detect changes in the environment, sensors such as rain sensors, and so on, as well as the installation of a solar system into the project to run for 24 hours.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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