IOT Based Air Quality Monitoring using particulate matter sensing in Online Think speak Cloud Server

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Abstract

This paper introduces a platform that utilizes IoT and cloud computing technologies for monitoring both indoor and outdoor pollution, allowing for environmental quality assessment anytime and anywhere. The system collects data from various locations within and outside a room at regular intervals, providing valuable information for characterizing the current conditions. The Pollution Monitoring System exemplifies the effective utilization of technology by monitoring and reporting environmental factors such as gas levels, smoke presence, temperature, and humidity. However, the communication between sensing hardware devices and the MQTT software protocols for online monitoring on any cloud platform presents certain challenges. To address these challenges, IoT-based hardware devices are employed, programmed to sense different air quality metrics and transmit the data to Thinkspeak analytics and the Cloud Platform for logging and conversion into a graphical format. The system utilizes MQTT protocol to establish communication between the hardware devices and the online cloud server. The primary objective of this research is to develop a real-time and cost-effective air quality monitoring system based on the Internet of Things. For monitoring dust levels, the system utilizes a dust level or particulate matter sensor, while temperature and humidity are measured using DHT11 sensors. Additionally, an ATmega328 controller with a NodeMCU ESP8266 development board equipped with a WiFi module is used to transmit readings to a ThingSpeak web channel platform, enabling immediate and real-time display of air quality. To enable remote communication, the concentration level is graphically monitored through channels on ThingSpeak. A threshold value has been established, so when pollutant levels reach high concentrations, the graphical curve rises to indicate the elevated dust concentration level. The study successfully designs a low-cost air quality monitoring system using NodeMCU and ThingSpeak.

Keywords: *IoT, ThingSpeak, NodeMCU, ESP8266, DHT11, ATmega328, MQTT.*

1.1 Introduction

Indoor air quality refers to the environmental conditions within buildings and public facilities that can impact individuals' respiratory and mental health. Traditionally, monitoring indoor air quality was not a priority for public establishments like shopping malls, hospitals, banks, restaurants, and educational institutions. However, the COVID-19 pandemic has brought attention to the importance of indoor air quality due to the rapid spread of the virus and its adverse effects. Unlike outdoor air, indoor air is constantly recirculated, leading to the accumulation of contaminants that can contribute to viral transmission. Several commercial methods are available for monitoring air quality, typically utilizing gas and particle sensors. This study proposes a cost-effective approach to develop a standardized pollution monitoring device using wireless technology, specifically the Internet of Things (IoT) and cloud computing. The paper outlines the creation of a cloud-based IoT system for monitoring air quality, accessible through a web interface or via a cloud server. Monitoring air quality is a global concern for both governments and individuals. Governments worldwide have invested significant resources in policies and solutions to address the issue of declining air quality. Air pollution is caused by particulate matter released from industries, automobiles, equipment, waste recycling, industrial operations, and households. Noteworthy pollutants include heavy metal dust, carbon monoxide, ozone, carbon dioxide, nitrogen dioxide, suspended particulate matter, hydrogen fluoride, sulphur oxides, and others. These pollutants enter the atmosphere, leading to severe health and environmental consequences.

1.2 MQTT Protocol:

MQTT is an OASIS communications standard for the Internet of Things (IoT). It is intended to be a very lightweight publish/subscribe message transport for linking remote devices with a tiny code footprint and low network traffic. MQTT is now utilised in a broad range of sectors, including automotive, manufacturing, telecommunications, oil and gas, and so on.

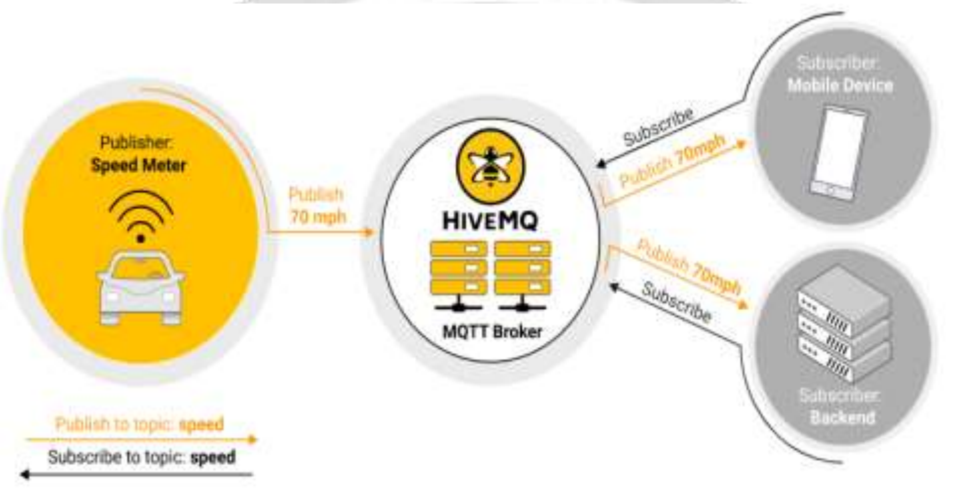

Fig :MQTT Publish/Subscribe Architecture

The primary advantages of MQTT are as follows:

1. Lightweight and efficient, reducing client and network bandwidth requirements.

2. Enables bidirectional communication between devices and servers, including the ability to broadcast messages to groups of items.

3. Scales effectively to handle large numbers of items.

4. Provides different Quality of Service (QoS) levels to ensure message reliability.

5. Supports persistent sessions, minimizing reconnection time over unstable networks.

6. Offers message encryption using TLS and supports client authentication mechanisms.

MQTT is a binary protocol where control components are represented as binary bytes instead of text strings. It employs a command and acknowledgment format, meaning that each instruction is accompanied by an acknowledgment.

1.3 System Structure:

The architecture of the implementation is illustrated in Figure 1. To detect pollution in the environment, the system utilizes the sharp dust sensor GP2Y1010AU0F, which features six pins. Additionally, a DHT11 sensor is employed to measure the surrounding temperature and humidity. Both sensors, the GP2Y1010AU0F and the DHT11, are connected to the atmega328 microcontroller, which is serially linked to the NodeMCU-12E ESP8266. The ESP8266 is further connected to the MQTT broker, which also serves the purpose of displaying the results. The sharp dust sensor GP2Y1010AU0F measures the analog data, which is then transmitted to the subscriber through the MQTT broker. The system can be divided into two sections: the first section consists of the sensors and the microcontroller, while the second section includes the MQTT broker and the result display. The ESP8266 NodeMCU-12E functions as a network gateway, acting as the interface between the Sharp dust sensor (GP2Y1010AU0F) and the DHT11 temperature and humidity sensor.

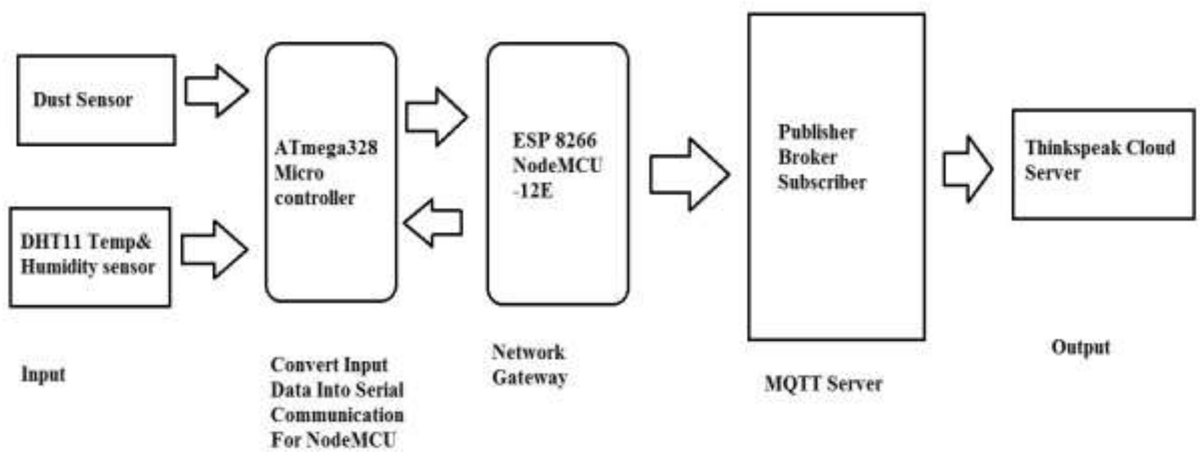

Fig : System Architecture

1.4 ThinkSpeak

ThingSpeak is an open-source software platform that facilitates communication with internet-connected devices. It is implemented using Ruby programming language. This platform simplifies data access, retrieval, and logging by providing an API for devices and integration with social network websites. Initially introduced in 2010 by ioBridge, ThingSpeak was designed to support IoT applications. Notably, ThingSpeak has incorporated support from MathWorks' MATLAB, a numerical computing program. This integration allows ThingSpeak users to analyze and visualize the data they submit using MATLAB, eliminating the need for a separate MathWorks MATLAB license. ThingSpeak has gained recognition and has been featured in articles on "Maker" websites like Instructables, Codeproject, and Channel 9.

Fig: Example OfThinkspeak Channel

1.5 Objective of the Paper:

1) The goal of this research is to create a real-time Internet of Things air quality monitoring system.
2) Using Cloud Server For Real Time Data Feeding, Monitoring and Logging.
3) Using MQTT protocol for Internet Communication.
4) Interfacing External Sensors and Hardware Directly With Cloud Server For interaction.

LITERATURE REVIEW

2.1 BACKGROUND

Ravi Kishore Kodali and Borade Samar Sarjerao,**2017**,National Institute of Technology Warangal,The suggested pollution monitoring system is built around a WiFi microcontroller ESP8266 nodemcu, a sharp dust sensor GP2Y1010AU0F (for particle measurement), and a MQ-7. Sensors for measuring carbon monoxide and the MQTT protocol ESP8266, GP2Y1010AU0F sharp dust sensor, and We constructed a low-cost MQ-7 (carbon monoxide) sensor. Implementation and maintenance, portability, and ease of use The subscriber can view the polluted content simply utilising a web browser. application for mobile A straightforward pollution monitoring system (particulate) measuring matter and carbon monoxide levels) device based on ESP8266 nodemcu microcontroller with MQTT protocol with A price of less than $40 has been provided.

JunHo Jo , ByungWan Jo , JungHoon Kim , SungJun Kim, and WoonYong Han,2020,Department of Civil and Environmental Engineering, Hanyang University, 04763 Seoul, Republic of Korea 2Smart IS, 22101 Incheon, Republic of Korea,,The creation of an IoT-based indoor air quality monitoring systems is reported in this research. Experiments were carried out. done in order to validate the air quality measuring equipment A platform-based technique proposed by the Ministry of Korea's environment. We tested the precision of indoor air quality. quality control and desired performance of the device. Experiments utilising the platform were also conducted. carried out and exhibited appropriate performance and convenience of the platform for monitoring air quality Several The platform's accomplishments included the following: (1) The indoor air quality may be efficiently checked Using IoT and the cloud, you may access information from anywhere and in real time. Technology of computation;(2) For platform and data security, the platform used Amazon Web Services as a certified web server; (3) the Smart-Air device has an expandable interface, and the web server is also easily extendable, allowing easy application to various environments through the addition of appropriate sensors to the device or the installation of more Smart-Air devices in appropriate monitoring locations.The gadget and platform will be tested further in the future. The experiment in this study focuses on validating the device's dependability and deploying the platform, where further experiments are required to assure data correctness over lengthy time periods. A ventilation system can also be linked to the platform. As a result, when the air quality is poor, the system can function automatically to enhance it.

T.Veeramanikandasamy, Gokul Raj.S, A.Balamurugan, A.P.Ramesh, Y.A.Syed Khadar,2020,One of the most significant risks in many sectors is air pollution. It is essential to monitor and guarantee that the workplace is safe and free of pollution. This IoT-based air quality monitoring and control system employs an embedded system to continuously maintain air quality in industrial workplaces and to show the measured air quality index (AQI) on the ThingSpeak IoT platform and the Virtuino mobile app display. It supports new technologies by monitoring real-time environmental data such as CO, CO2, and ammonia gas concentrations, particulate matter PM2.5 and PM10 in air, and temperature-humidity. The data is kept in the cloud server and may be sent to the user through e-mail.The system has maintained the air quality index (AQI) in the workplace if the threshold values for gas concentrations and PM are exceeded. This technology will eliminate the source of explosions and fires caused by gas leaks. Real-time air quality monitoring and control system based on IoT to decrease detrimental impacts in the industrial workplace.

Anabi Hilary Kelechi1, Mohammed H. Alsharif, Chidumebi Agbaetuo, Osichinaka Ubadike1 Alex Aligbe1, Peerapong Uthansakul, Raju Kannadasanand Ayman A. Aly,2021,This study successfully developed a low-cost air quality monitoring system design using Arduino and ThingSpeak, demonstrating that an air quality system can be constructed utilising low-cost technologies, such as Arduino and ThingSpeak. The project was tested in several areas, including unit, sub-unit, system, acceptability, and programme testing. In all testing settings, the system operates admirably. This method may be used to create a smartphone app that can be simply deployed to monitor air quality across the spectrum, ultimately benefiting public health.

Chaitra N, Bhavana S, Vilas Reddy D N, Nikhil AS,2020,Temperature, pressure, humidity, and, most crucially, PM2.5 AND PM10 detection play a vital part in residential, industry, and air quality monitoring. The system we are constructing is very modest when compared to prior and current air excellence intensive automobilee plans. This design provides the benefits of stability, low power usage, and self-sufficiency. Users may watch real-time information and track changes in the data. This design will also be useful for checking the atmospheric conditions in a specific area, which are difficult for humans to measure. By using trending approaches, this solution contributes to quality of life support.

3 PROBLEM IDENTIFICATION

3.1 Problem Statement

Air quality is extremely significant in terms of human safety, security, and health. While expanding large-scale manufacturing and urbanisation generate massive cities, these activities have a variety of negative environmental consequences.

Similarly, one issue is the degradation of air quality in several Indian cities. Particulate matter (PM2.5) is the largest contributor to air pollution, affecting human health difficulties such as asthma and other respiratory disorders. According to one study, those who inhale particulate matter in the air are more likely to get lung cancer than nonsmokers who are exposed to secondhand smoking.

3.2 Followings are the Points for the Problem Statement:

a) Previously in the past data’s has to be fed in the website manually for analyzing purpose.

b) Online Live Data Monitoring is not Available.

c) Hardware and Internet Interface is Challenging and Future Promising Task.

d) For Live Data Feeding and Graph Analysis and Internet Communication MQTT Protocol based Publisher,Subscriber,Broker is need.
c) Cloud Space server is need for the Interaction.

METHEDOLOGY

4.1 Methedology

The goal is to gather data from sensors and communicate it to the user anytime the user wants to check the appropriate particle matter data (GP2Y1010AU0F sharp dust sensor) and carbon monoxide level (MQ-7). The Esp8266 NodeMCU-12E microcontroller serves as a gateway server for connecting to the Internet through Wi-Fi. It functions as a network, with control over the sensors that provide updates on the particulate matter value (PM 2.5), carbon monoxide value, and component condition. The data is protected by the Security Protocol (Transport layer security).For this study, we utilized a sharp dust sensor GP2Y1010AU0F (which detects analogue values) and a DHT11 (which measures both Temperature and Humidity). Furthermore, the data is continually kept in the MQTT Server. The benefit of utilizing the MQTT protocol with the Secure Socket Layer (SSL) cryptographic protocol is that no misleading data is saved alongside the needed data, and security is maintained.

4.2 Methods used For this Study is as Follows:

1) For programming controllers, use the Arduino Ide Embedded Programming Platform.

2) C and C++ are the official programming languages of the Arduino Ide software.

3) Communicating with the Thinkspeak Cloud Server using MQTT Protocol in Header Files.

4) An ATmega328 Programmable Hardware Microcontroller was also utilised, which was programmed using the Arduino IDE Software.

5) The Thinkspeak Cloud Server is used to monitor and log data from the IoT Controller NodeMCU.

6) ESP8266 Processor-based Hardware NodeMCU Controller, Foot IoT Communication

7) Using a Wi-Fi signal as a source to link the NodeMCU Controller to the internet.

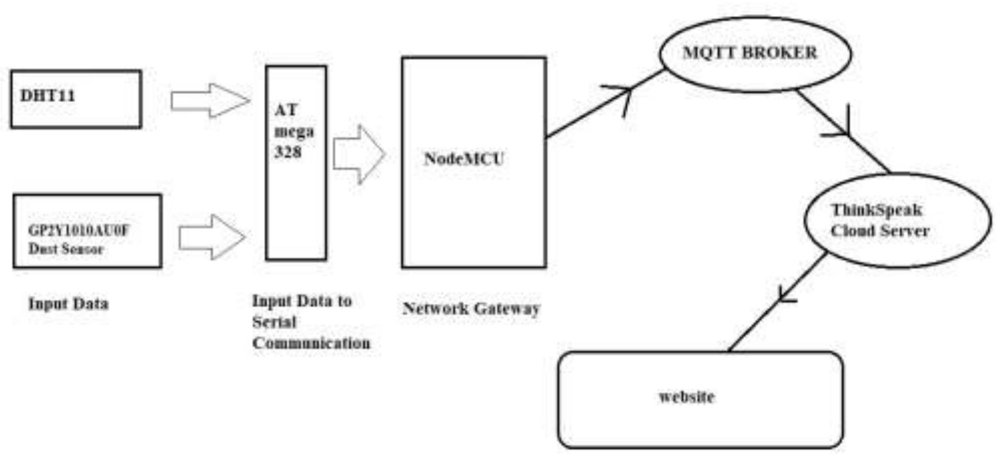

Fig : Block Diagram Explanation Of system

4.3 Working Procedure:

1) DHT11 is used to measure ambient temperature and humidity, while Dust Sensor (GP2Y1010AU0F) is used to measure dust levels ranging from 0.1 to 0.10 mg/m3.

2) The Atmega328 Microcontroller is utilised to receive data from sensors and calculate the surrounding parameters based on the computations in the Header File.

3) Using the serial Communication Program, send the data output to the NodeMCU.

4) The NodeMCU receives serial communication and filters the data from the characters.

5) Identify the specific character sign and filter the data.

6) Using logical operations, convert the character to an integer.

7) Use the configured wifi id and password to connect.

8) Use the Thinkspeak Header File to upload the data to the Thinkspeak Server.

9)All programming is done in the Arduino IDE software in C and C++.

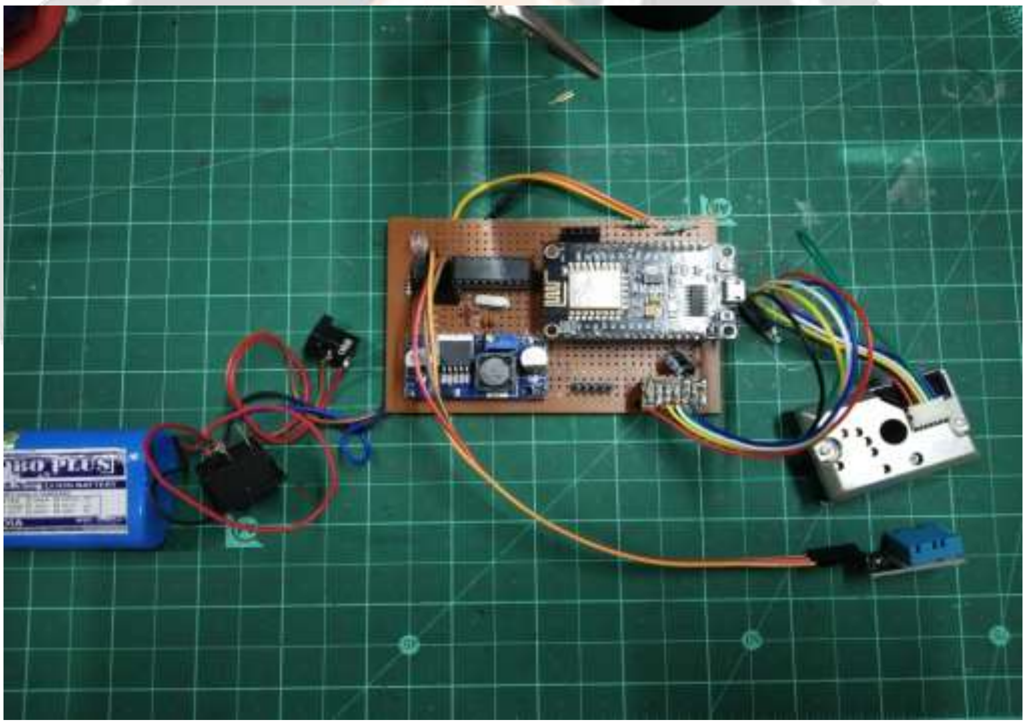

Fig : Real Combined Circuit with ATmega328 ,NodeMCU,Dust Sensor,DHT11 Temp and Humidity sensor

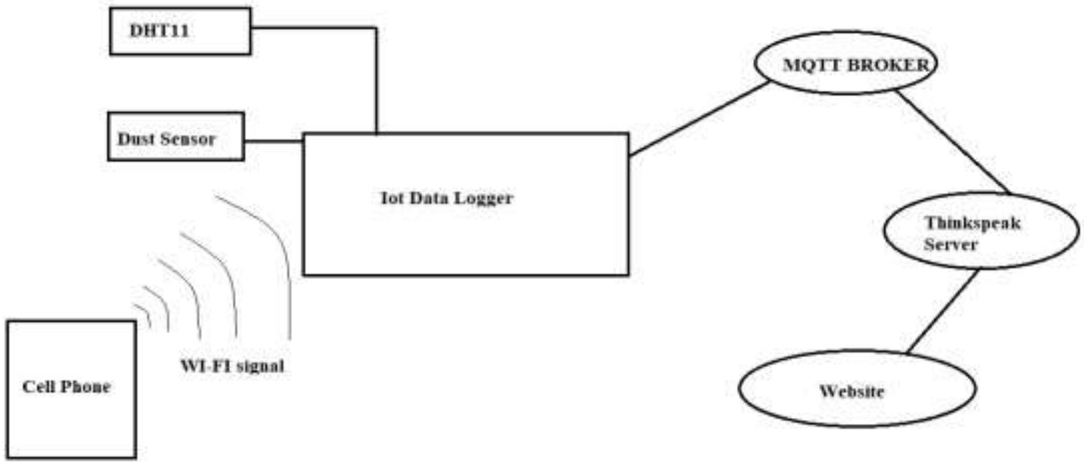

Fig: Block Diagram For Wi fi Communication

RESULT

5.1 Result

As from the above Programming the Output Received in the Thinkspeak Server as Followings:

1) Temperature Data
2) Humidity Data
3) Dust Level Concentration

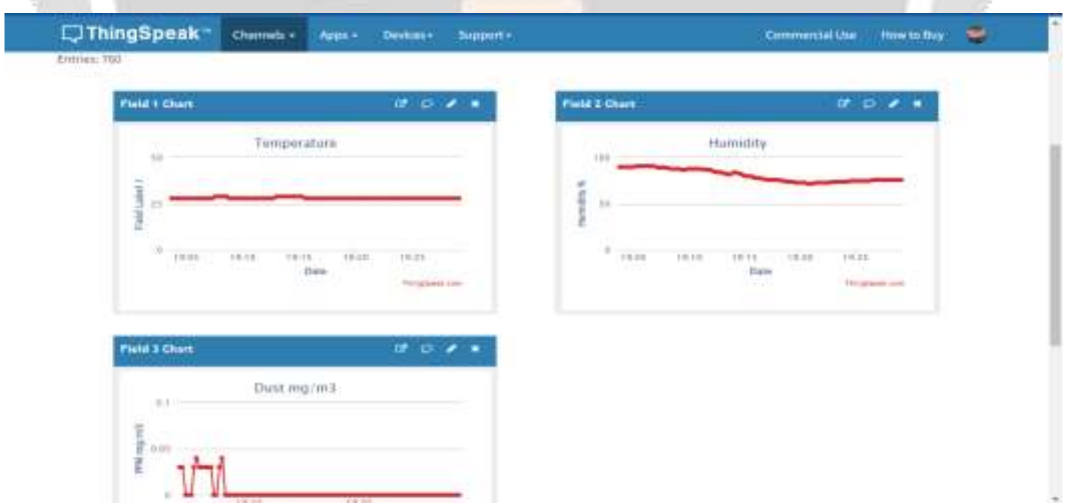

Fig : ThinkSpeak Server all Sensors Data Outputs

Connection established successfully in between NodeMCU Hareware and Thinkspeak Cloud Server.The Result Output Obtained From the Programming and Real Time Data Monitoring of Sensors Output From Iot based hardware NodeMCU is shown Below.

1) Surrounding Temperature Data Out

To take temperature data from the DHT11 sensor and upload it to the Thinkspeak Sever. Temperature readings are monitored and saved in the figure below. Temperature readings in the surrounding area will be constant, so an external heat source (such as finger touching) is used to cause variation in the graph.

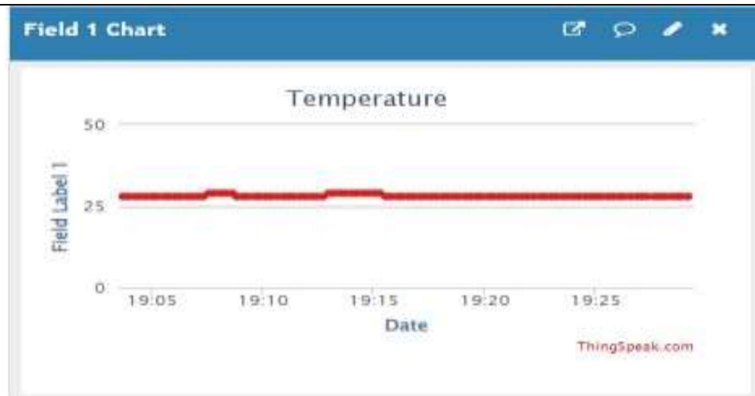

Fig : Surrounding Temperature data output in Thinkspeak Server

2) Surrounding Humidity Data

To take Humidity data from the DHT11 sensor and upload it to the Thinkspeak Sever. Humidity readings are monitored and saved in the figure below. Humidity readings in the surrounding area will be constant, so external dehumidifier is used(example Air Conditioner) to Reduce Humidity Value.

Fig: Surrounding Humidity Value in Thinkspeak Server website

3) Surrounding Dust Concentration In mg/m3

To take Dust Concentration data from the DHT11 sensor and upload it to the Thinkspeak Sever. Dust Concentration readings are monitored and saved in the figure below. Dust Concentration readings in the surrounding area will be constant, so external Dust or particle source such as smoke is used to change the reading or for variation in reading.

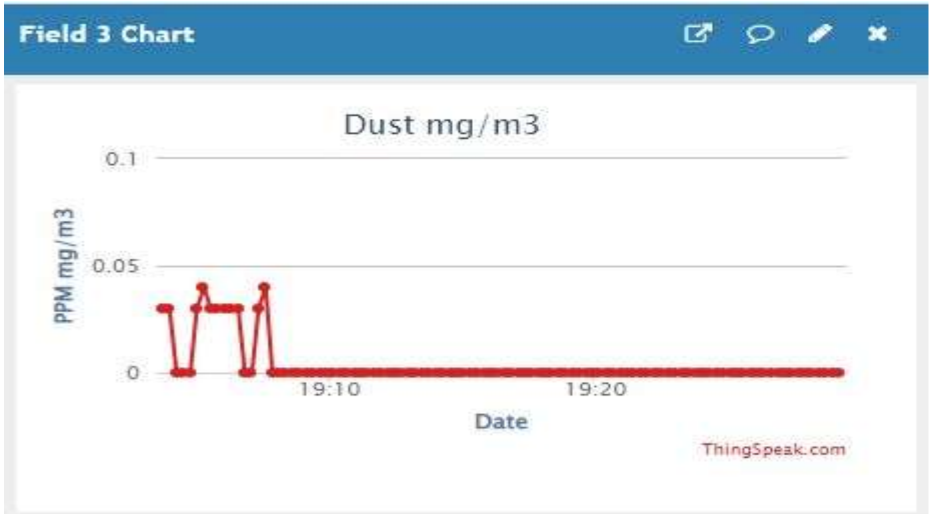

Fig: Surrounding Dust Concentration Value in Thinkspeak Server website

Fig : External Dust or smoke Source for variation in reading

5.2 Comparison Graphs In Between the Parameters

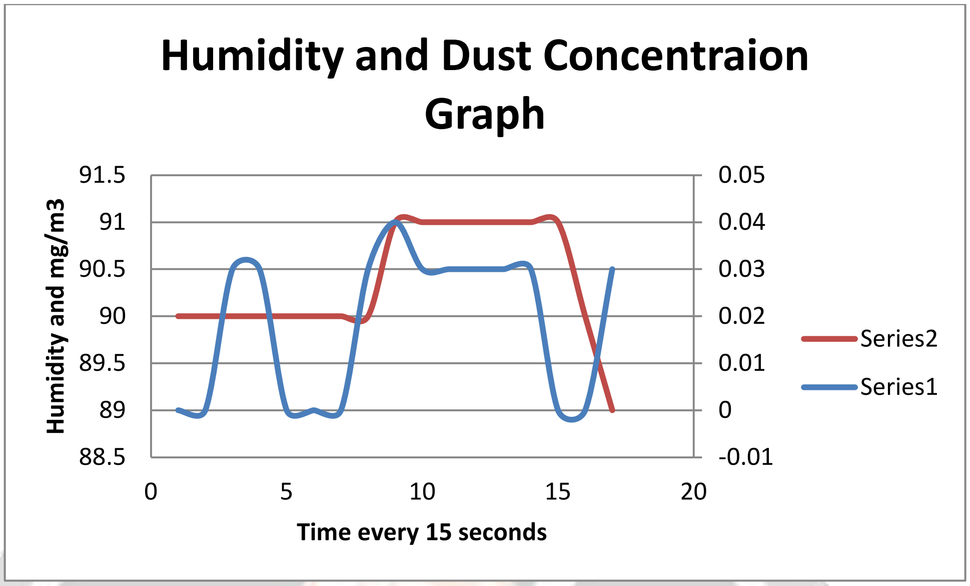

Fig : Humidity and Dust Concentration(mg/m3) Graph From The Readings

The advantage of reading log data is that it allows for subsequent remapping and comparative analysis of different parameters. As in the graph above, which compares humidity and dust concentration. It demonstrates that when humidity rises, dust concentration falls. Correct, since the water vapours in the air settle down the very small dust particles.

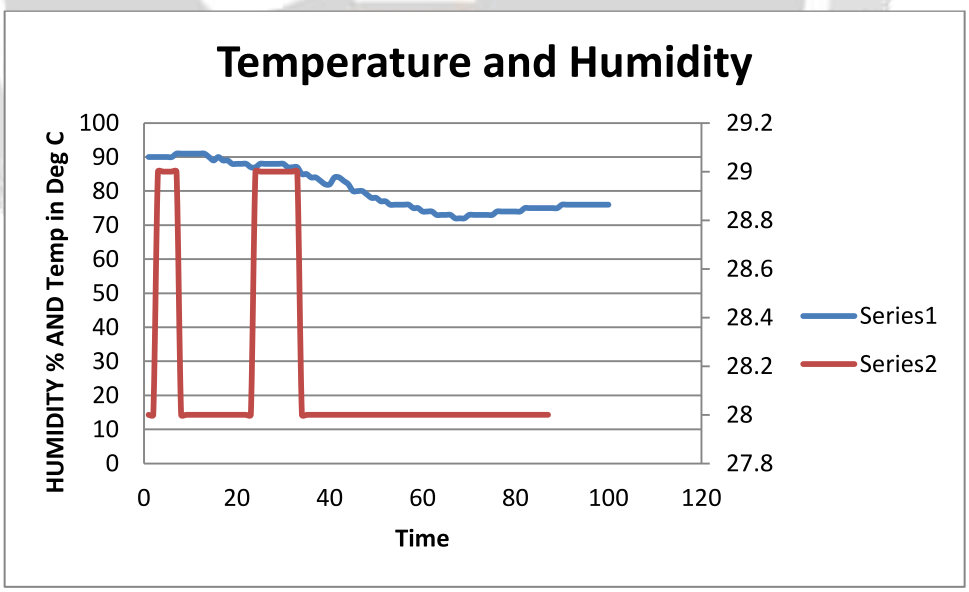

Fig : Comparision Grpah In between Temperature and Humidity

Similar to the comparison graph between dust concentration and humidity shown above, a comparison graph between additional parameters such as temperature and humidity may be created and analysed. When a result, as the temperature rises, the humidity falls and Vice versa.

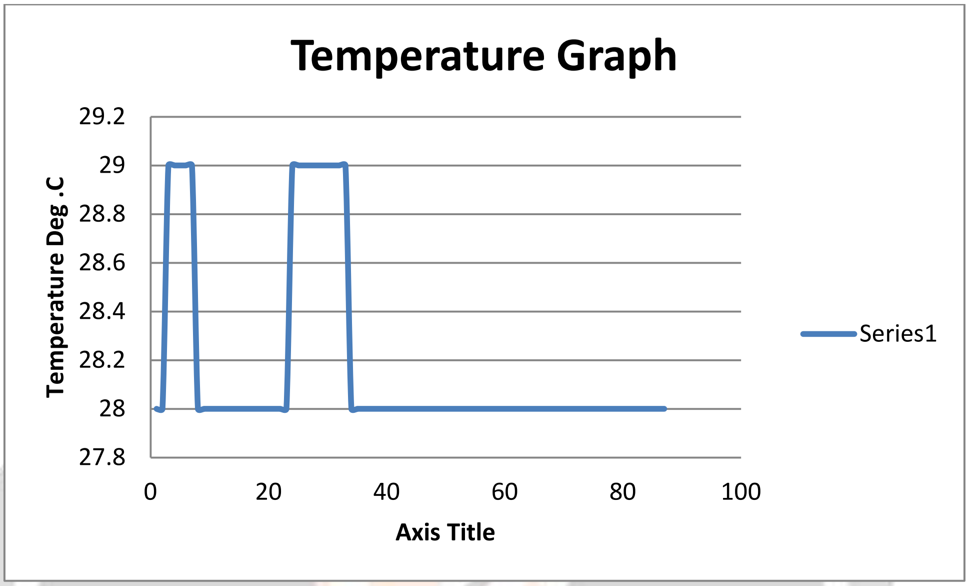

Fig : Single Temperature Variation Graph From log data

This is a single parameter graph from log data; when compared to the Thinkspeak graph, it is clear that the Thinkspeak graph provides a graphical record of all the data, testing data, and regular stable data. However, only precise temporal data that was collected for the final reading is necessary for analysis; otherwise, no data is required for analysis.

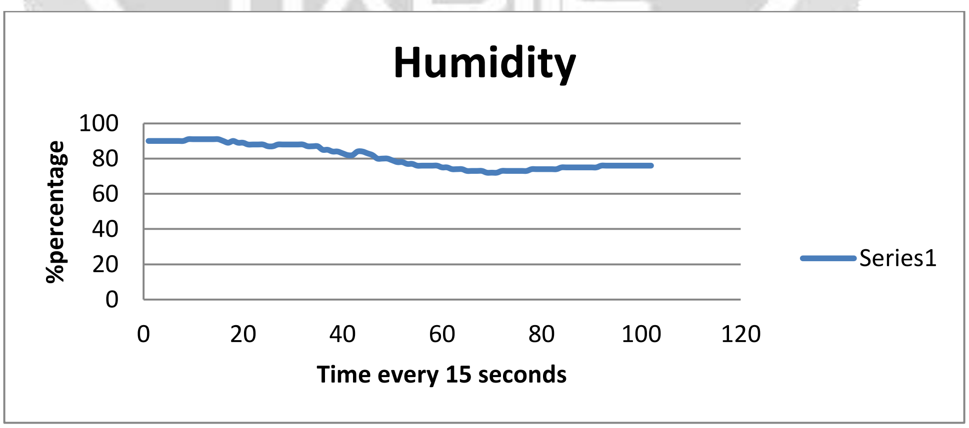

Fig: Humidity variation graph from log data

Log data humidity graph,log data graph is clear and reveals specifics like the humidity level at a certain moment or overall period. Most essential, just the necessary data may be transformed into a graph. It is not necessary to plot all of the readings graphs from today, tomorrow, and ten days later. Only a specific day or time graph may be taken and converted into graphical form from Excel format.

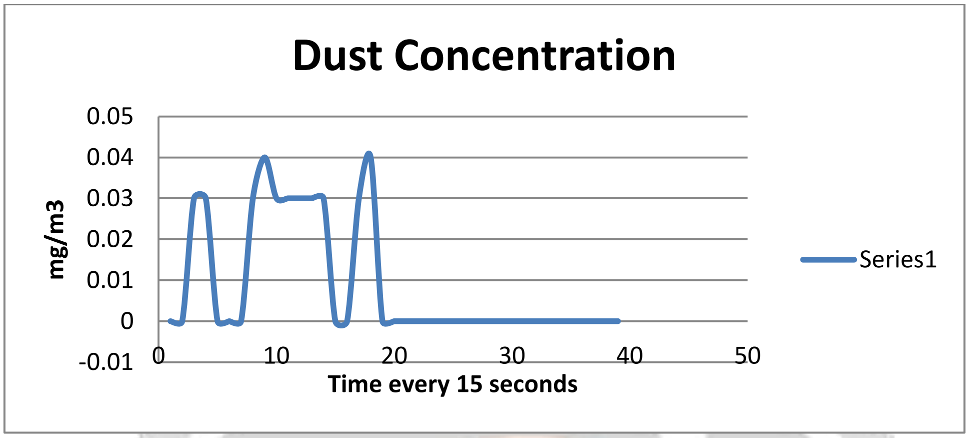

Fig : Dust Con centration Graph from log data

Dust concentration level is used to illustrate Particulate matter in the surrounding environment, and its unit is mg/m3 (milligrammes per cubic metre) or PM2.5. Using the Sensor GP2Y1010AU0F Fine dust particles as little as 1mg/m3 can be detected. Because the majority of the particulate matter content in the room is constant, smoke sources are utilized to alter the readings so that sensor operation and live data feeding may be shown on the Thinkspeak Cloud Server Website.

6.1 Conclusion

NodeMCU Controller is an excellent and low-power consumption module for IOT-based live data monitoring and logging with sensors. Because many sensors provide 5v output but the NodeMCU can only receive 3.3v input, an additional controller or hardware is necessary to receive the sensors data and transfer it to the NodeMCU Controller. Because Thinkspeak Cloud Server is a Cloud Platform, it requires a subscription (paying version) to update data in real time. As an example, in this project, a Trail version account is built that updates data every 15 seconds. Many other IoT-based hardwares are too expensive and need extensive Embedded programming. Low-cost IoT-based hardware is employed in this system, together with the C and C++ programming languages for Embedded Programming and Server Interfacing. For programming, the Arduino Ide open source software compiler is utilized. For connectivity with the Thinkspeak server, the MQTT internet communication protocol is already included in the ESP8266.h header file. In this project, two programs are used: one for the ATmega328 Controller to communicate serially with the NodeMCU and another for the NodeMCU to post data to the internet. Other Cloud systems can also be used to upload and analyze data. Thinkspeak's shortcoming is that it does not display comparison graphs or graphs for certain time periods separately.Although it offers advanced features such as Matlab analysis for advanced analysis.

6.2 FUTURE SCOPE

1) Multiple advanced and necessary sensors can be utilised in conjunction with controlling devices to monitor and control the environment or topic.

2) It may be employed in the medical area for real-time health monitoring and control.

It has several uses in the medical area for monitoring patients' health and taking appropriate procedures to regulate their health.

3) In the case of a specialised environmental control system.

Vehicles and systems based on artificial intelligence (AI).

4) This system provides real data input to the cloud server, allowing the AI analysis-based cloud server to solve complex issue solutions.

such as 24x7 traffic updates and implementing safety measures by analysing motorist behaviour using AI technology.

5) Using the ESP32 Board controller with the camera option, live views may be sent to the AI server for analysis.

6) Using the MQTT Protocol, a self-contained server or website may be built for secure and safe data storage.

7) Because the future is heavily reliant on the internet, this gadget may assist in monitoring numerous factors and controlling them using logical functional programming with an advanced cloud server to solve complex problems.

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