Design and Implementation of an IoT-Based Air Quality Monitoring System

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Abstract—To Design and advance a less expensive air air pollution monitoring system. The proposed machine alert workers, notify facts of polluted place that has been checked for the on the spot surroundings. The proposed device has more than a few parameters such as Air Quality, Temperature and Humidity sensors with ESP8266 microcontroller which collects and add statistics into the cloud using ESP8266 Wi-Fi module. The statistics is transmitted to the cloud platform the usage of MQTT (Message queuing Telemetry Transport) protocol and indicators the consumer thru an application. The proposed device has more than a few functions like in enterprise where the pollution levels take a look at of risky gasses is paramount. Further air pollution data is used to alert the employees about the air first-class in their environment are no longer proper for fitness.

***Index Terms*—— Internet of Things, Blynk, Arduino, arduino IDE, sensors, Air pollution**

I. INTRODUCTION

In this cutting-edge generation, air air pollution is one of the hazardous troubles in human society. This is a international confronted problem. The ever growing degrees of carbon dioxide in the atmosphere, is main to the temperature rise. We want an correct air air pollution monitoring gadget that is mild in weight, effortless to take care of and can display a large assortment of air pollution (CO, NO2, and CO2) emitted from motor vehicles. It is apparent that these who work in a manufacturing unit or plant will be a ways extra at chance of inhalation of detrimental chemical substances and gases due to their extended publicity to emissions. Air air pollution provides to the detrimental circumstance that makes damaging have an effect on on residing things. It is one of the actual difficulty for the whole world.

Air air pollution is a international trouble which includes global organizations, governments, and the mass media. Any utilization of herbal belongings at a greater charge than the nature's capability to re-establish itself can carry about illness of plants, air, and water. Other than human exercises, there are a couple of intermittent attribute cycles that moreover end result in launch of volatile stuff. Beside human made things to do herbal catastrophe such as volcanic eruption may additionally end result in the illness of air. Globalization is substantial cause for contamination. In most instances air pollution can be: Carbon Monoxide: A gasoline that originates from the eating of burning of fossil fuels, typically in autos. It can not be viewed or noticed. It have an effect on human beings feeling dizzy and worn-out and offers them headaches.

Toxic air pollutants: are created in chemical flowers or are emitted when fossil fuels are burned. They are the reasons for cancer. Other toxics can additionally purpose beginning defects. Ozone (O3): Secondary toxin framed by using artificial response of unstable herbal compounds inside the sight of sunlight. It minimizes the lung characteristic and motives respiratory symptoms, such as coughing, asthma, and respiratory associated problems. Nitrogen Dioxide (NO2): Fuel ignition such as automobile fuel, electric powered utilities, timber burnings and industrial boilers. It is the purpose for lung associated diseases. Sulfur Dioxide (SO2): It comes from combustion of

excessive sulphur gasoline as properly as herbal disaster such as volcanoes.

II. RELATED STUDY

Monika Singh et al. in August 2019, he proposed an air pollution monitoring system. This system uses an Arduino microcontroller coupled with an MQ135 and MQ6 gas sensor that senses different types of gases present in the environment. It was then connected to a Wi-Fi module that connects to the internet and the LCD is used to display the output to the user and a buzzer when the ppm exceeds a certain threshold. Their applications were industrial perimeter monitoring, indoor air quality monitoring, location selection of reference monitoring stations, making data available to users Yamunathangam et al. in November 2018 used IoT by measuring gas concentration using various sensors which were observed through arduino serial monitor. This data is collected in Thing speak channels using an ethernet shield which is available for further processing. These analyzed results were viewed through matter-of-fact speech in a graphical format. The mean pollution level was then calculated using Matlab analysis and the timed results were displayed via an Android application. Furthermore, based on the location, the air quality index value was obtained through an Android application. Along with this, the health effects have also been displayed in this app so that users can be aware of the pollution levels. Poonam Pal et al. in October 2017 he developed an air monitoring system using an Arduino microcontroller. They used an MQ135 gas sensor to sense different types of hazardous gases and an arduino to control the whole process. The MQ135 gas sensor provides output in the form of voltage levels and needs to be converted to PPM. A Wi-Fi module was used to connect the entire process to the Internet, and an LCD was used for visual output. When the value is below 1000 PPM, the LCD and web page will display "Fresh Air" and when the PPM exceeds the limit, the buzzer will beep and the LCD and web page will display "Bad Air, Open Windows". If it increases by 2000, the buzzer will keep beeping and the LCD and web page will show “Danger! Move to fresh air.” Nitin Sadashiv Desai et al. in 2017, he proposed a system that consists of a beagle bone connected to air pollution measurement sensors such as carbon dioxide [CO2], carbon monoxide [CO], and a noise sensor. Harsh Gupta et al. in 2019, they introduced an IOT-based air pollution monitoring system consisting of sensors for continuous monitoring of temperature, humidity, carbon monoxide, smoke, LPG, PM2.5 and PM10 in the atmosphere. Their work developed one-way communication between Thing Speak, an open source cloud platform, and an Android application. A Raspberry Pi was used as a gateway for the hardware system interface. Once the Firebase API was included in the Android or iOS app, Firebase features like Analytics, Authentication, Storage, Reporting, Hosting, Crash Reporting, Realtime Database, etc. were used. Graphs were rendered in Thing Speak according to the received sensor data and the same were visualized in the Android application in tabular format.

III. METHODOLOGY

In order to enable continuous and adaptive tracking of urban air pollution, this project focuses on developing an Internet of Things (IoT)-based real-time air quality monitoring system that combines wireless communication, cloud computing, multi-pollutant sensors, and AI-driven analytics. By guaranteeing real-time data gathering, enhanced spatial coverage, and AI-based calibration procedures, the system is intended to address the drawbacks of conventional air quality monitoring methodologies. The deployment of both mobile and fixed sensors, real- time data transmission, cloud-based storage, machine learning models for predictive analytics, and automated alarm systems for emergency response are all part of the methodology’s organized approach. For efficient environmental management, the implementation entails sensor positioning, wireless communication configuration, data processing, visualization, and interaction with governmental networks.

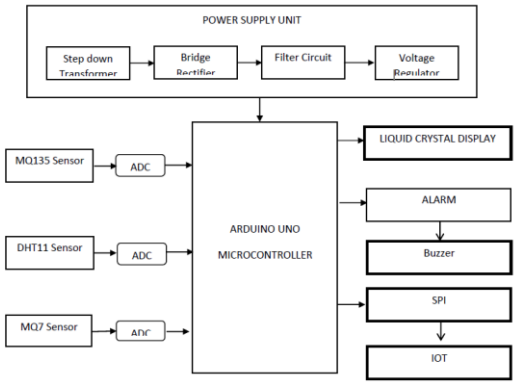


Fig.2 Block Diagram

(i) IOT Cloud Service: Interconnection and communication between various physical devices that have an IP address and are able to access the internet is referred to as the "Internet of Things" (IoT), which is a name that characterizes the phenomenon. The scope of this network is always broadening. It is possible to deploy applications that manage, control, and monitor connected devices thanks to the Internet of Things platform, which is a collection of components. The term "Internet of Things" refers to the interconnection of various physical objects such as automobiles, buildings, and other machinery that have computing power, software, sensors, actuators, and network connections built into them. The term also refers to the process of collecting data remotely from devices that are linked, as well as the connectivity between devices that are both independent and secure. The processing of data that takes place on web-connected computers in enormous data centers, which are commonly referred to as the cloud, is one of the most important factors that has enabled everyday objects to become part of the Internet of Things (IoT). As seen in the picture Fig.3, the Internet of Things Cloud Service is depicted.

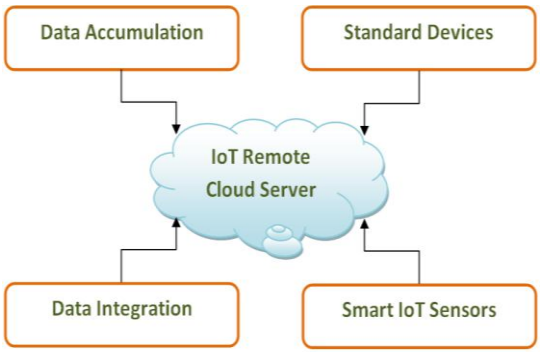


Fig.3 IOT Cloud Service

(ii) MQ135 Sensor: The MQ-135 gas sensor can be implemented to detect smoke and other harmful gases. It has the potential to detect various harmful gases including NH3, NOx, alcohol, benzene, smoke and CO2. The MQ135 gas sensor has high sensitivity to ammonia, sulphide and benzene vapor, also sensitive to smoke and other harmful gases. This module uses the MQ-135 air quality detector and hazardous gas detector chip. Components such as the LM393 analog comparator chip on this module make it easy to integrate this module into a project that can detect hazardous gases. The module requires a 5V supply and provides a digital logic output (1 or 0) and an analog level output (0-4V). The digital logic output is LOW (0) when no gas is detected, but goes HIGH (1) when the hazardous gas concentration in the environment reaches a set threshold value set by a potentiometer on the module. The analog level output provides an output voltage ranging from 0 to 4 V based on the hazardous gas concentration in the environment; 0V for lowest concentration, 4V for maximum concentration.

Fig.4 MQ135 Sensor

(iii) LCD Display: Information such as temperature, battery voltage, and the area's location may be shown on the LCD display. Used in liquid crystal cell displays or other applications using light-emitting diodes. Among these uses are the dot matrix and segment displays for numerical and alphanumeric characters. Display unit with a bigger 16x2 dimension that can display updated user information from the database with columns and rows. The following figure Fig.5 shows the LCD display.

Fig.5 LCD Display

(iv) DHT11: The DHT11 is a commonly used temperature and humidity sensor that comes with a dedicated NTC for temperature measurement and an 8-bit microcontroller for outputting temperature and

humidity values as serial data. The DHT11 is a commonly used temperature and humidity sensor. The sensor comes with a dedicated NTC for temperature measurement and an 8-bit microcontroller for outputting temperature and humidity values as serial data. The sensor is also factory calibrated and therefore easily interfaced with other microcontrollers. The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. So if you are looking for measurements in this range, then this sensor could be the right choice for you.

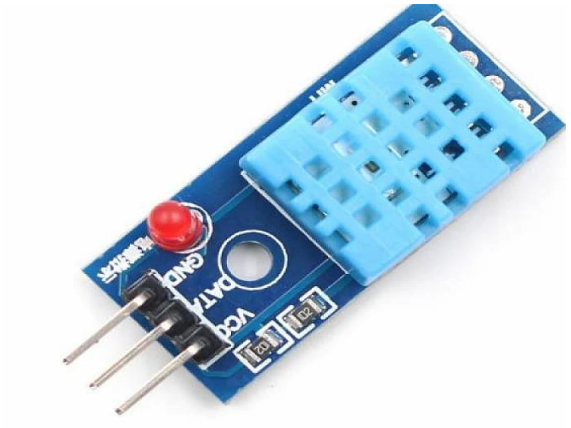


Fig.6 DHT11 Sensor

(v) Node MCU

ESP2866 Node MCU V3 is an open-source firmware and development kit that plays a vital role in designing your own IoT product with a few lines of Lua script. Multiple GPIO pins on the board allow the board to be connected to other peripherals and are capable of generating PWM, I2C, SPI and UART serial communications.

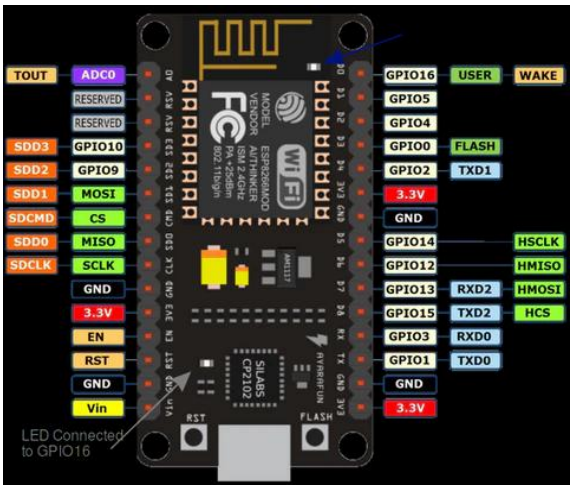


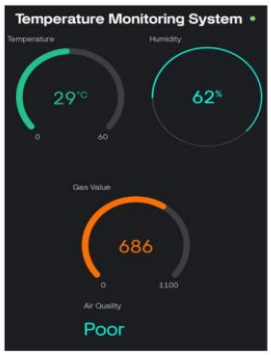
Fig.7 Nodemcu

IV. RESULTS AND DISCUSSIONS

The AI-enabled IoT-based smart Air Quality Monitoring System was successfully developed, deployed, and tested under real-world environmental conditions. The system demonstrated strong stability, accuracy, and real-time responsiveness across all evaluation metrics. During testing, the system correctly measured temperature, humidity, gas concentration, and AQI levels with stable and consistent readings. The AQI calculation reflected environmental changes effectively, showing increased values during polluted conditions and lower values during clean air scenarios.

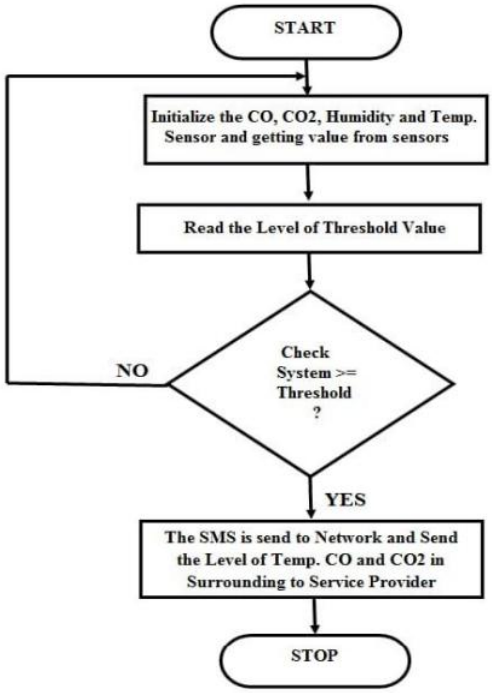
IoT-based monitoring of air quality is shown to be significantly more effective than previous methods, according to the findings. This allows people and authorities to provide real-time updates on the condition of pollution problems, such as changing traffic flow or controlling factory emissions. The implementation of pollution control regulations and environ- mental protection is made more accessible to governments. However, certain matters remain unresolved. Sensors must be properly calibrated to provide accurate readings due to the unpredictable weather conditions. There are security concerns regarding the protection of pollution data from hacking or tampering. In addition, a large network of sensors can be difficult to scale because of the high cost involved in setting up and maintaining it. Improvements to such systems require future research aimed at improving accuracy of sensors, data security, and expanding network capacity at lower costs. By integrating IoT monitoring with smart city initiatives, such as traffic management, industrial emissions reduction, and urban planning, pollution reduction can be further reduced. By utilizing IoT, real-time monitoring of air quality can help citizens protect themselves, support environmental policies, and contribute to the improvement of urban living. The technology is highly effective.

The hardware prototype design with correct power supply methods and the final design of the thermo electric cooling system are shown in Figures 7 and 8, respectively, of the suggested technique.



V. ARCHITECTURE OF PROPOSED METHODOLOGY

The Internet of Things (IoT) is primarily concerned with connecting smart devices to the Internet by combining the advantages of the OSI layered architecture. In this work, we propose an array of MQ135 mote air quality gas sensors that are used to measure the concentration of air pollutants in the air. MQ135 gas sensors connect to a small fixed platform equipped with others [7]. We mainly used Node MCUs, which are open source development boards with ESP8266- 12E chips. The MQ135 gas sensor is used to collect gas concentration measurements. This sensor data would be captured and sent to the MCU node for IoT (Internet of Things) based data collection



VI. CONCLUSION

The car parking fire smoke alert monitoring system is developed in order to generate a more systematic and efficient parking system by using Arduino and android application. This system that able to track and trace the fire smoke in the parking area by processing the smoke sensitivity value that are taken by the MQ-2 natural gas smoke sensor. Then, this prototype system will notify the student by generating fire smoke information by using a multiple and distinct Arduino devices. Moreover, the student also needs to register their information by using an android application and the information will be stored into the database. This IoT system is easy to install and maintain as it requires very low technical skills and knowledge for device handling.

REFERENCES

[1] Frank Gilliland, "Air Pollution Exposure Assessment for Epidemi- ologic Studies of Pregnant Women and Children: Lessons Learned from the Centers for Children's Environmental Health and Disease Prevention Research" Department of Preventive Medicine, VOLUME 113 — NUMBER 10 — October 2005

[2] Jen-Hao Liu, "AN AIR QUALITY MONITORING SYSTEM FOR URBAN AREAS BASED ON THE TECHNOLOGY OF WIRELESS SENSOR NETWORKS", INTERNATIONAL JOURNAL ON SMART SENSING AND INTELLIGENT SYSTEMS, VOL. 5, NO. 1, MARCH 2012

[3] K. P. Moustris,1 P. T. Nastos,2 I. K. Larissi,3 and A.G.Paliatsos4 "Ap- plication of Multiple Linear Regression Models and Artificial Neural Networks on the Surface Ozone Forecasting the Greater Athens Area, Greece" Hindawi Publishing Corporation Advances in Meteorology, Volume 2012, Article ID 894714, 8 pages, May 2012

[4] MOHIEDDINE BENAMMAR, "Real-Time Indoor Air Quality Monitoring Through Wireless Sensor Network", International Journal of Internet of Things and Web Services, Volume 2, 2017

[5] Philipp Schneider, "Mapping urban air quality in near real-time using observations from low cost sensors and model information", NILU-Norwegian Institute for Air Research, PO Box

100, Kjeller 2027, Norway, Environment International 106 (2017), orm 5 May 2017; Accepted 8 May 2017

[6] Nuria Castell, "Can commercial low-cost sensor platforms con- tribute to air quality monitoring and exposure estimates?", Environment International, 28 December 2016

[7] Jaehyun Ahn 1," Indoor Air Quality Analys,is Using Deep Learning with Sensor Data", Sensors (Italicized), 28 October 2017

[8] Jinhuang Lin, An Zhang, Wenhui Chen, and Mingshui Lin. Estimates of daily PM2.5 exposure in Beijing using spatiotemporal kriging model. Sustainability, 2018.

[9] Huzein Fahmi Hawari, Aideed Ahmad Zainal, and Mohammad Radzi Ahmad. Development of real-time Internet of Things (IoT) based air quality monitoring system. Indonesian Journal of Electrical Engineering and Computer Science, 2019.

[10] Mehmet Tas¸tan and Hayrettin Go¨kozan. Real-time monitoring of indoor air quality with Internet of Things-based e-nose. Applied Sciences, 2019.

[11] Wei Jian Ng and Zuraini Dahari. Enhancement of real-time IoT-based air quality monitoring system. International Journal ofPower Electronics and Drive System, 2020.

[12] Shola Usha Rani, S. Rajarajeswari, Jerry George Jaimon, and Roshan Ravichandran. Real-time air quality monitoring system using MQ135 and ThingsBoard. Journal of Critical Reviews, 2020.

[13] Dan Zhang and Simon S. Woo. Real-time localized air quality monitor- ing and prediction through mobile and fixed IoT sensing network. IEEE Access, 2020.

[14] Yuda Irawan, Refni Wahyuni, Muhardi, Hendry Fonda, Muhammad Luthfi Hamzah, and Rometdo Muzawi. Real-time systemmonitoring and analysis-based Internet ofThings(IoT) technology in measuring outdoor air quality. International Journal of Interactive Mobile Technologies (iJIM), 2021.

[15] Alessandro Zivelonghi and Alessandro Giuseppi. Smart Healthy Schools: An IoT-enabled concept for multi-room dynamic air quality control. Internet of Things and Cyber-Physical Systems, 2024.

[16] Kennedy Okokpujie, Etinosa Noma-Osaghae, Modupe Odusami, Samuel John, and Oluga Oluwatosin. "A smart air pollution monitoring sys- tem". International Journal of Civil Engineering and Technology, 9(9):799–809, 2018.

[17] Zeba Idrees, Zhuo Zou, and Lirong Zheng. "Edge computing-based IoT architecture for low-cost air pollution monitoring systems: A compre- hensive system analysis, design considerations development". Sensors, 18(3021):1– 23, 2018.

[18] Julio Buelvas, Danny Munera, Diana P. Tobon V., Johnny Aguirre, and Natalia Gaviria. "Data Quality in IoT-Based Air Quality Monitoring Systems: A Systematic Mapping Study. Water, Air, Soil Pollution", 234(248), 2023.

[19] T. Lakshmi Narayana, C. Venkatesh, Ajmeera Kiran, Chinna Babu J, Adarsh Kumar, Surbhi Bhatia Khan, Ahlam Almusharraf, and Mohammad Tabrez Quasim. "Advances in real-time smart monitoring of environmental parameters using IoT and sensors". Heliyon, 10 (2024) e28195.

[20] Syaiful Bachri Mustamin, Muhammad Atnang, Sahriani, Nurhikmah Fajar, Sri Kurnian Sari, and Muammar Reza Pahlawan. The Application of Machine Learning and Intelligent Sensors for Real-Time Air Quality Monitoring: A Literature Review. Journal ofScientific Insight, 1(3):119-130, 2024.

[21] Claudia Banciu, Adrian Florea, and Razvan Bogdan. Monitoring and Predicting Air Quality with IoT Devices. Processes, 12(1961), 2024.

[22] Reginald Ekene Ogu, Isaac A. Ezenugu, Nkwachukwu Chukwuchekwa, Gloria A. Chukwudebe, and Ifeyinwa E. Achumba. A Robust IoT-based Air Quality Monitoring Node for Multi-Location Deployment. International Journal of Engineering Research & Technology (IJERT), 11(3):146-151, March 2022.

[23] Renjith V. Ravi, Pushan Kumar Dutta, and Wen-Cheng Lai. An IoT-Based Air Pollution Monitoring System for Smart City Applications. Conference Paper, January 2022.

[24] Iftikhar ul Samee, Muhammad Taha Jilani, and Husna Gul A. Wahab. An Application of IoT and Machine Learning to Air Pollution Monitoring in Smart Cities. IEEE Conference Paper, 2019.

[25] Emmanuel Oyo-Ita, Ukoette Jeremiah Ekah, Prince Onebieni Ana, and Igwe Otaba Ewona. Development of a Smart Air Quality Monitoring

System Using Wireless Sensors. Advances in Research, 24(6):50-59, 2023.

[26] Saini, E. S., Singh, N., Pal, D., Singwaliya, H. V., Tyagi, P., & Yadav, S. A. (2024). IOT Based Air Quality Monitoring Device. International Journal of Scientific Research in Engineering and Management, 8(11).

[27] Nayak, S. P., Rout, S., Das, S., & Patra, S. S. (2021). Error rate reduction of Air Quality Parameters in Health Care Industry using SD-IoT Environment. Proceedings of the 2021 19th OITS International Conference on Information Technology (OCIT).

[28] Zúñiga, A., & Muñoz, P. (2025). An interdisciplinary approach for air quality assessment: biomonitoring using Tillandsia bergeri and risk perceptions in the environmentally sacrificed province of Chacabuco, Chile. Environmental Monitoring and Assessment, 197(3), 123-135.

[29] Ravi, R. V., Dutta, P. K., & Lai, W. C. (2023). An IoT-based air pollution monitoring system for smart city applications. IET Conference Proceedings, 2022(26).

[30] Kortoçi, Pranvera, et al. "Air pollution exposure monitoring using portable low-cost air quality sensors." Smart health 23 (2022): 100241.