A REVIEW ON AN INDOOR AIR QUALITY MONITORING SYSTEM BASED ON THE INTERNET OF THINGS (IoT)

1st Komal Meena
Mechanical Department
MITADT University, Loni Kalbhor
Pune, India
komalmeena525@gmail.com

2nd Sandeep Thorat
Mechanical Department
MITADT University, Loni Kalbhor
Pune, India
sandeep.thorat@mituniversity.edu.in

3rd Mangesh Dhavalikar
Mechanical Department
MITADT University, Loni Kalbhor
Pune, India
mangesh.dhavalikar@mitunivers ity.edu.in

***Abstract*— The review of an IoT based air purifier or air cleaner is a device that removes contaminants from the air in a room to improve indoor air quality. It consists of an air quality-sensing device regarding indoor temperature, humidity, and wind speed, and pays more attention to air quality. The Internet of Things has proven its potential to solve problems where the presence of information can contribute greatly to a solution or become the solution itself. With air purifiers being able to clean the air indoors, the users cannot check the consistency of such a process and no provision to compare the quality of air they get to breathe. With the IoT based system it not only will monitor the air quality but also trigger an alarm when the quality goes down beyond a certain level, meaning when there are sufficient amounts of harmful gases present in the air like carbon dioxide, smoke, alcohol, benzene, ammonia and nitrogen oxide.**

***Keywords— IoT, Sensors, Air monitoring*.**

I. INTRODUCTION

Pollutants such as harmful gases, particulate matter, others gases or molecules contribute to air pollution thus affecting human health and the surrounding environment. Advanced technologies and increased urbanization are some other factors that contribute to air pollution and this causes major health issues. According to a survey conducted on iqair.com India ranks 5th as the most polluted country. The most polluted city is the capital Delhi were people inhale toxic air every second. The central pollution control board proposed a monitoring system known as the national air quality monitoring program. The different types of air pollutant present in the air are: Ozone, CO, NH3, SO2, NO2, PM-2.5 and PM-10. Breathing them can lead to severe health effects [21].

With the increase air pollution the need for an indoor air purifier has also increased and with the advancement in technologies a smart air purifier can be built and is also the necessity of the hour. IoT has proved is potential over the period of time [22]. With manual purifiers the user has no feedback or control system but with an IoT based purifier there is a room for the user to check air quality of the room and automated on/off system for the purifier when pollutants increase or decrease around the threshold point. Purifiers in other words are air cleaners that remove all the harmful contaminants, pollutants or other molecules from the air. Thus adaptation to these leaving habits is the new trend [23]. The Internet of Things reports physical objects that are built with sensors, software and other technologies and IoT connects and exchanges data with other system, it is a communication network. IoT based system smartly monitors the air and triggers an alarm when the quality of air falls below a threshold point, which implies that when toxic gases increases the purifier starts and shuts down automatically after purifying the air. Portable air purifier are also being adapted in the society as an precaution [24].

II. METHOD AND MATERIAL

Basic components that complete the IoT based air purifier are the sensors, controllers and the air purifying system. The same components are discussed in details in the further sections.

A. Sensors

TABLE I. DIFFERENT SENSORS USED

Sr No	Sensors	Working
1	Laser Dust Sensor	Laser diode acts as the light source, the laser emitting diode emits the pulse and simultaneously the fan drives the air in the sensor and detects the air.
2	Volatile Compound Sensor	The senor measures the acidic concentration in the air, such gases burn in the air increasing the ppm output of the sensor.
3	Carbon Monoxide Sensor	The high level of CO triggers an alarm in the sensor with the accomplice of a microchip.
4	Carbon Dioxide Sensor	It is a gas sensor which detects the quantity of IR radiation absorbed by CO2, basically measures the level of carbon dioxide.
5	Temperature Humidity Sensor	Observes minute changes in the surrounding such as the altering current or the varying temperature. There are three basic types: thermal, resistive, capacitive.

6	Ammonia Sensor	The ammonia detector has a electrolyte solution with three different electrode which maintain the current to detect ammonia. Thus the level og ammonia is measured.
7	Nitrogen Dioxide Sensor	When the sensor detects the gas it sends an equal amount of electric current through it thus measuring the gas.
8	Sulphur Dioxide Sensor	Works on the electrochemical principle, the gas diffuses in the sensor triggering the current thus sensing high levels of gas.
9	Hydrocarbon Sensor	Works electrochemically allowing the gas to pass through the membrane to diffuse with an electrode to be oxidized or reduced.

Each sensor is set at a different threshold value depending on the preset value of the according to the WHO. When it reaches that triggering point the sensor alarms the controller, here the IoT is used to transfer data.

B. Controller

TABLE II. TYPES OF CONTROLLER

Sr No	Controller	Working
1	Raspberry pi	The controller receives data through IoT and works according to the threshold value set. It triggers the working of the purifier and sets back to open when the pollutant is below preset value.
2	Arduino uno	The working of Arduino uno is similar to that of the raspberry pi as mentioned above.
3	Smart Cloud	There are different cloud computing program available which have open access to different libraries and controlling methods thus these can act as a controller and be used for the system.

Different systems use different controller according to availability and requirement but the main objective is to control the air purifying system according to the input received from the sensor.

C. Air Purifier working technologies

TABLE III. TYPES OF PURIFIER

Sr No	Air Purifier	Working
1	High Efficiency Particulate Air (HEPA)	It works as a mesh and filters molecule up to and larger than 0.3 microns. Used mostly in filters as it does not produce ozone and is efficient.
2	Activated Carbon Technology	The carbon varies in sizes and absorbs most of the pollutants. As the pore size varies a number of different elements can be filtered through it.
3	UV Technology	This technology captures Particulate matter that is dust and kills bacteria that are around. Not as efficient as the previous two filtering methods.
4	Negative Ion Technology	This method discharges positive and negative ions which then attract other molecule and attach to the water molecule present in the air thus becoming heavier and eventually falling down.
5	Ozone Technology	These purifiers are not recommended as they produce ozone that is harmful for environment and human health.

Air purifiers are based on different cleansing technologies but most of the filters use HEPA technology as it is 99.97% efficient and filters contaminants upto 0.3 microns and does not produce ozone which makes it safe for individual health and the environment.

D. Methodology

The Working of the system is explained with the help of block diagram. The papers reviewed are based on similar working and objective.

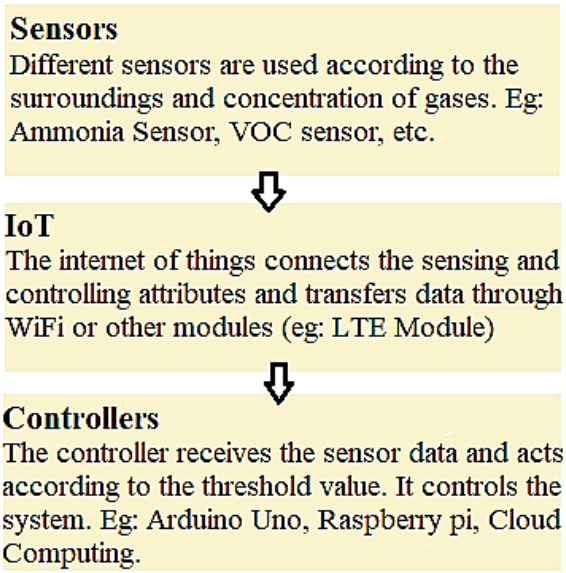

Fig. 1. Working of the system.

III. LITERATURE REVIEW

The papers reviewed in this study for smart air purifier are all based on IoT and have similar methodology. Below is the brief introduction in this literature.

Syed Faiazuddin et al [1] work on an IoT based air purifier using CCS811 CO2 Air Quality Sensor, Grove- Air quality sensor v1.3, DHT 11 Temperature and humidity sensors and using control systems that are Raspberry Pi4, and, Arduino Uno and for programming these systems the following systems were embedded Python, PHP, MYSQL, Qt5. The same was stored in ThingSpeak cloud for monitoring the air quality over a period of time. Kim Ungtae et al [2] worked on monitoring three different contaminants the particulate matter, Volatile Organic Compound and, carbon dioxide. A comparative study was done between the indoor and outdoor air quality and stored in cloud. Jun Ho Ju et al [3] build a purifying system for subway tunnels in Incheon South Korea. The system purified Particulate matter 2.5 and 10; Sensors triggered due to set threshold thus the controller takes action. An amazon cloud computing controller was used here which was also used as a storage system for comparative study of the air quality. Junho Ju et al [4] in this paper they measured the concentration of VOC, CO, CO2, and, aerosol using different sensors, for data transfer an LTE module was used. STM 32

F407IG microcontroller was used which had ARM 32-bit Coretex M4 as the base. It was successfully implemented in the university. Liang Zhau et al [5] proposed the monitoring of temperature and humidity, CO2, dust and, formaldehyde using detectors. The paper shows the use of Wi-Fi for transfer of data and Modbus and LoRa as the controller and cloud storage for the system. Rafia Mumtaz et al [6] proposed an indoor air purifier consisting of eight sensors to detect the levels of NH3, CO, CO2, NO2, CH4, PM 2.5 and, Temperature and humidity in the air. The model reports the real time air quality through a web portal using mobile and Wi-Fi/GSM module. Use of Neural Network in the system proves 99.1% efficiency of the system using long and short term memory (LSTM). Siavash Esfahani et al [7] worked on a system to monitor VOC, CO2, PM 2.5, PM 10, Temperature, Humidity, and, illuminance also uses in-situ as a module. It has an ESP 32-bit microcontroller in the system with the IoT data transfer. Paulo Rafael Meris et al [8] proposes an air purifier with LPG detector it uses detectors for smoke, methane, LPG, carbon monoxide, carbon dioxide, and, PM2.5 in the air and triggers the controller through IoT. Controllers used in the experimentation are a combination of Arduino Uno and Raspberry Pi. Praveen Kumar Sharma et al [9] proposes an air quality monitoring system for gases like CO, CO2 , NO2 , particulate matters (PM 10 /PM 2.5 /PM 1) each sensor is set at a threshold value according to the safe class mentioned by the central pollution control board of India. B Jayasree et al [10] monitors and controlled the air quality using a low air quality detector and ESP 32-bit microcontroller. The IoT platform used in the system is Blynk IoT. M.F.M Firdhous et al [11] experimented on the ozone concentrations around a photo copying machine the sensor detects the air quality and sends real time data through Bluetooth and connected the module through local Wi-Fi , it also alarms the user when the ozone concentrations increases beyond a threshold value. Aditya Asabe et al [12] proposed an indoor air purifying system for industrial use. The purifier eliminates particles upto 10 microns which are visible to eyes, It has sensors to monitor the air and the data is analysed through Ansys Fluent Software. Wen-Tsai Sung et al [13] detects carbon dioxide in the air and through the wireless module sends data to Arduino Uno development board and ESP8266 Wi-Fi wireless transmission modules. Anubhav Aryan et al [14] uses different sensors to detect contaminants in the air and then uses transmits by low power, low-cost ARM based minicomputer Raspberry pi. Youngtae Choe et al [15] proposed an indoor air purifier for school in Korea. It detected the particulate matter 2.5 and CO2 in the classroom and purified the same without any external factors. Solongo Od et al [16] detected the particulate matter and CO2 in the air and then uses the IoT platform to transfer data to the controller. An app was developed for the end user to monitor the quality of air. Junho Ju et al [17] Proposed an air purifier for the kitchen to detect gas, temperature, humidity, and, pressure. The sensor used was Bosch BME680 sensor then a microcontroller is used in the system which uses the IoT as the base for the functioning. Michal Gabriel A Mapili et al [18] proposed a purifier which uses the Kalman filter to purify the air. It detects CO, No2, NH3, and Particulate matter 2.5 in the air; it uses ThingSpeak Internet of Things as the base and signals the controller. It successfully enhanced the indoor air quality. Jithina Jose et al [19] used the sensors BME680 from bosch, SGP30 and CCS811 to detect the pollutants in the air and LPWAN (Low Power Wide Area Network) for the transfer of data; For the controller of the system it used LoRa thus completing the system. Fadili Pradityo et al [20] proposed a combine methodology of IoT and Fuzzy logic to improve the AQI (air quality index). It monitors carbon dioxide and particulate matter 10 in the air, it uses Arduino Uno and Raspberry Pi as the controller, IoT for cloud storage and Fuzzy logic for monitoring the two constituents in the air. Kavi K Khedo et al [21] uses a network of sensors to monitor the air, uses an algorithm Recursive Converging Quartiles for the feedback system. Jungkwon Son et al [22] produced an indoor air purifier for dust particles with uses laser dust sensor to detect it and IoT provides the base of data transfer to the controller. Anindya Ananda Hapsari et al [23] detects CO2, Humidity, dust, and, temperature using different sensors. Methodology is the same it is based on IoT and uses message query telemetry transport (MQTT).

IV. Conclusion

The papers reviewed in the study show a similar pattern of methodology used overall. The development in the field of IoT has proved is potential over the period of time. Using the same with purifier makes it smart and handy for the end user. According to the surrounding environment and requirement purifiers can be built with different sensors also the controllers can be used according to the manufacturing ease and cost of production. Smart air is the necessity in the present times, especially with Covid-19 cases in the country.

References

[1] Faiazuddin, Syed, M. V. Lakshmaiah, and K. Tanveer Alam. "Design and Implementation of IoT based Indoor Air Quality Monitoring and control system." Solid State Technology, 2020. PP 5152-5166.

[2] Kim, Ungtae, Yong-Chul Kim, and Sooyeong Kwak. "Iot based indoor air quality monitoring system." The Journal of the Korea Contents Association 16, no. 2, 2016. PP 143-151.

[3] Jo, Jun Ho, ByungWan Jo, Jung Hoon Kim, and Ian Choi. "Implementation of iot-based air quality monitoring system for investigating particulate matter (Pm10) in subway tunnels." International Journal of Environmental Research and Public Health 17, no. 15, 2020. PP 5429.

[4] Jo, JunHo, ByungWan Jo, JungHoon Kim, SungJun Kim, and WoonYong Han. "Development of an IoT-based indoor air quality monitoring platform." Journal of Sensors 2020. PP 1-14.

[5] Zhao, Liang, Wenyan Wu, and Shengming Li. "Design and implementation of an iot-based indoor air quality detector with multiple communication interfaces." IEEE Internet of Things Journal 6, no. 6 2019. PP 9621-9632.

[6] Mumtaz, Rafia, Syed Mohammad Hassan Zaidi, Muhammad Zeeshan Shakir, Uferah Shafi, Muhammad Moeez Malik, Ayesha Haque, Sadaf Mumtaz, and Syed Ali Raza Zaidi. "Internet of things (Iot) based indoor air quality sensing and predictive analytic—a covid-19 perspective." Electronics 10, no. 2, 2021. PP 184.

[7] Esfahani, Siavash, Piers Rollins, Jan Peter Specht, Marina Cole, and Julian W. Gardner. "Smart City Battery Operated IoT Based Indoor Air Quality Monitoring System." In 2020 IEEE SENSORS, IEEE, 2020. PP 1-4.

[8] Meris, Paulo Rafael, Ericson Dimaunahan, Jennifer C. Dela Cruz, Nemilyn A. Fadchar, Mark Christian Manuel, Jan Chastise C. Bonaobra, Ferdyn Joshua I. Ranosa, Jeshua Luis D. Mangaoang, and Patrick C. Reyes. "IOT Based–Automated Indoor Air Quality and LPG Leak Detection Control System using Support Vector Machine." In 2020 11th IEEE Control and System Graduate Research Colloquium (ICSGRC), IEEE, 2020. PP. 231-235.

[9] Sharma, Praveen Kumar, Tanmay De, and Sujoy Saha. "IoT based indoor environment data modelling and prediction." In 2018 10th International Conference on Communication Systems & Networks (COMSNETS), IEEE, 2018. PP. 537-539.

[10] Jayasree, B., T. Subash, V. Priyadharsan, and N. Priya. "Implementation and Measurement of IOT Based Indoor Air Quality Monitoring System." International Journal of Scientific Development and Research 6, no. 4, 2021. PP 372-376.

[11] Firdhous, M. F. M., B. H. Sudantha, and P. M. Karunaratne. "IoT enabled proactive indoor air quality monitoring system for sustainable health management." In 2017 2nd International Conference on Computing and Communications Technologies (ICCCT), IEEE, 2017. PP. 216-221.

[12] Asabe, Aditya, Deepak Tiwari, Manu Dubey, Vedant Joshi, Shardul Shrikhande, and R. Mohan. "Centralized Smart Air Purifier System for Industrial Applications." In International Virtual Conference on Industry 4.0, Springer, Singapore, 2021. PP. 169-179.

[13] Sung, Wen-Tsai, and Sung-Jung Hsiao. "Building an indoor air quality monitoring system based on the architecture of the Internet of Things." EURASIP Journal on Wireless Communications and Networking 2021, no. 1, 2021. PP 1-41.

[14] Aryan, Anubhav, B. S. Jnanesh, Pramita Soans, and S. H. Prateeksha. "An Iot Based Air Pollution Control System." PhD diss., CMR Institute of Technology. Bangalore, 2021. PP 1-30.

[15] Choe, Youngtae, Jun-shup Shin, Jinhyeon Park, Eunchae Kim, Narae Oh, Kihong Min, Dongjun Kim, Kyunghwa Sung, Mansu Cho, and Wonho Yang. "Inadequacy of air purifier for indoor air quality improvement in classrooms without external ventilation." Building and Environment 207 (2022): 108450.

[16] Od, Solongo, Hao-Chen Hsu, and Jong-Bi Wei. "Improve the Indoor Air Quality Based on Internet of Things." In 2021 IEEE 3rd Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS), IEEE, 2021. PP. 105-108.

[17] Wall, Dylan, Paul McCullagh, Ian Cleland, and Raymond Bond. "Development of an Internet of Things solution to monitor and analyse indoor air quality." Internet of Things 14 (2021): 100392.

[18] Mapili, Micah Gabriel A., Kathleen Anne D. Rodriguez, and Julius T. Sese. "Smart Air Filtration System Using IoT and Kalman Filter Algorithm for Indoor Air Quality and Plant Monitoring." In 2021 IEEE 11th International Conference on System Engineering and Technology (ICSET), IEEE, 2021. PP. 309-314.

[19] Jose, Jithina, and T. Sasipraba. "Indoor air quality monitors using IOT sensors and LPWAN." In 2019 3rd International conference on Trends in electronics and informatics (ICOEI), IEEE, 2019. PP. 633-637.

[20] Pradityo, Fadli, and Nico Surantha. "Indoor air quality monitoring and controlling system based on IoT and fuzzy logic." In 2019 7th International conference on information and communication technology (ICoICT), IEEE, 2019. PP. 1-6.

[21] Khedo, Kavi K., Rajiv Perseedoss, and Avinash Mungur. "A wireless sensor network air pollution monitoring system." arXiv preprint arXiv:1005.1737, 2010.

[22] Hapsari, Anindya Ananda, Asif Iqbal Hajamydeen, Devan Junesco Vresdian, Mauludi Manfaluthy, Legenda Prameswono, and Eddy Yusuf. "Real Time Indoor Air Quality Monitoring System Based on IoT using MQTT and Wireless Sensor Network." In 2019 IEEE 6th International Conference on Engineering Technologies and Applied Sciences (ICETAS), IEEE, 2019. PP. 1-7.

[23] D'Amato, Gennaro, Carlos E. Baena-Cagnani, Lorenzo Cecchi, Isabella Annesi-Maesano, Carlos Nunes, Ignacio Ansotegui, Maria D'Amato, Gennaro Liccardi, Matteo Sofia, and Walter G. Canonica. "Climate change, air pollution and extreme events leading to increasing prevalence of allergic respiratory diseases." Multidisciplinary respiratory medicine 8, no. 1, 2013. PP 1-9.

[24] Shafique, Kinza, Bilal A. Khawaja, Farah Sabir, Sameer Qazi, and Muhammad Mustaqim. "Internet of things (IoT) for next-generation smart systems: A review of current challenges, future trends and prospects for emerging 5G-IoT scenarios." Ieee Access 8, 2020. PP 23022-23040.

[25] Cho, Minji, Sangsu Lee, and Kun-Pyo Lee. "How do people adapt to use of an IoT air purifier?: From low expectation to minimal use." International Journal of Design 13, no. 3, 2019. PP 21-38.

[26] Cooper, Elizabeth, Yan Wang, Samuel Stamp, Esfandiar Burman, and Dejan Mumovic. "Use of portable air purifiers in homes: Operating behaviour, effect on indoor PM2. 5 and perceived indoor air quality." Building and Environment 191, 2021. PP107621.