A study of Multi-Level Smart Air Purifier System

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ABSTRACT

Air pollution is increasingly recognized as a pervasive threat to health, particularly with the rise in indoor activity. Given the shifting lifestyles leading to increased indoor activities, ensuring optimal indoor air quality is imperative for maintaining overall health and wellness. Leveraging IoT technology, this work proposes a study of smart air purifier system capable of real-time monitoring and decision making. The system integrates multiple purification stages and UV sterilization to address diverse air quality concerns. At its core lies an Arduino Uno microcontroller, facilitating remote control and monitoring through the Blynk Cloud platform. By detailing both hardware and software components,along side integration with BlynkCloud, the research work aims to provide a comprehensive solution for maintaining clean indoor air.

Keywords

Air Quality Index (AQI), High-Efficiency Pollution Absorbing (HEPA).

1. INTRODUCTION

The escalation of air pollution has prompted apprehensions regarding its diverse consequences, including impacts on global climate, deforestation rates. Recent studies indicate a historic high in carbon dioxide levels. While people spend significant time in- doors for work, study, and daily life, the indoor air quality directly impacts their well-being. Consequently, the demand for accurate air purifier systems, like air purifiers, has surged, driving research into their development [1]. Air purifiers encompass various types, including mechanical filters, adsorption purifiers, electrostatic purifiers, and ultraviolet purifiers, each targeting different pollutants. These pollutants, ranging from particulate matter to nitrogen oxides, pose significant environmental and health risks, such as respiratory issues and acid rain formation. Advancements in air purifier technology now emphasize multi-functionality and intelligent operation, integrating features like automatic detection and adjustment of air quality using components like the ESP8266 microcontroller [1]. Additionally, linking purifier systems with mobile devices enables remote control, offering users greater convenience and comfort in managing air quality. The escalating levels of air pollution have triggered concerns over its multifaceted impacts, spanning global warming, deforestation, and health hazards. Recent findings highlight a historic milestone, with carbon dioxide levels surpassing 415 parts per million (ppm) [2]. Despite the significant indoor time spent for work and daily activities, the quality of indoor air remains pivotal for well- being. Consequently, the demand for effective air purification solutions, notably air purifiers, has surged, driving research into their development. Air purifiers encompass diverse types, from mechanical filters to ultraviolet purifiers, each targeting distinct pollutants. The pollutants such as particulate matter and nitrogen oxides, pose substantial environmental and health risks, such as respiratory ailments and acid rain formation. Advancements in air purifier technology prioritize versatility and intelligent operation, integrating features like automatic air quality detection and adjustment using components like ESP8266 microcontroller [2]. Moreover, the integration of purifier systems with mobile devices enables remote control, offering users enhanced convenience and comfort in managing indoor air quality.

2. LITERATURE SURVEY

The literature survey table serves as a concise summary of recent studies and advancements in the realm of indoor air quality management and air purification systems. Each entry in the table sheds light on diverse technologies and methodologies utilized to tackle the complexities of maintaining healthy indoor air environments. By outlining the pros and cons of each paper, the table offers valuable insights into the strengths and limitations of various air quality monitoring and purification approaches. From low-cost IoT-enabled monitoring systems to innovative air purifier designs, the literature provides a glimpse into the ongoing efforts to enhance indoor air quality for the betterment of human health and comfort.

Table 1. Literature Survey

Paper	Technology	Advantages	Remarks
[1]	Low-cost Sensors IoT Platform, Android Application, Botanical Solutions	Low-cost Implementation, Remote Monitoring.	Accuracy of Low-cost Sensors, Limited Sensor Coverage.
[2]	IOT, HEPA Filters and Activated Carbon Filters, Gas Sensor (MQ135)	Improved Air Quality, Real-time Air Quality Monitoring.	Initial Cost Maintenance, Reliability.
[3]	Activated Carbon Filter Screen	Electrostatic Purifiers, Mechanical Filter	Reliance on Mobile Device, Complexity of Design Method
[12]	Market Research and Literature Reading	Enhanced User Satisfaction	Complexity

[13]	IoT-Based System, Smart-Air Air Quality Sensor	Remote Monitoring Capability	Initial Setup Complexity

3. METHODOLOGY

Smart air purifiers offer personalized insights and recommendations based on comprehensive air quality data, empowering users to make informed decisions about the indoor environments. One notable feature of the air purifier is its integration with the Arduino UNO series microcontroller, enabling seamless interfacing with the Blynk application cloud for remote monitoring and control. This functionality allows users to conveniently manage and oversee the device from any location, introducing a new level of convenience to air quality management. Additionally, this work introduces a conceptual and functional model of an air purification system tailored for small public spaces or apartments, further emphasizing the importance of remote control capabilities through the Blynk Cloud platform. Air is filtered in the following steps:

- Air is sucked through the opening in the front panel of Air Purifier and is guided to the first filter.
- The first filter is the so called the 'Dust Filter' & its main function is to remove the big particles present in the air. It removes the particles of 3to10 micron size.
  - The second filter is the so called 'Pre Filter' & its main function is to absorb the air contaminants such as hairs and other matter visible to the naked eye. It removes particles of size 10 to 25 micron size.
- The last filter is the Fine filter, which removes most of the particles with a diameter larger or equal to 1 to 3micron size.

An LCD screen has been incorporated into the system to provide users with real-time updates on air parameters and the current quality of purified air. The Arduino software is compatible with the Node MCU and Blynk application library. It will read the data from the MS1100 on Analog 0 and from a DHT11 on digital Pin 2. The sensors data will read every 2 seconds. UV sterilization enhances the system's efficiency in eliminating harmful microorganisms. The air is circulated within the room after purification by the air purifier. This process is repeated to get the purified air throughout the room. This helps to maintain the environmental air clean and healthy. Depending on the air purification system capacity, it will purify different volumes of air present in the different sizes of rooms.

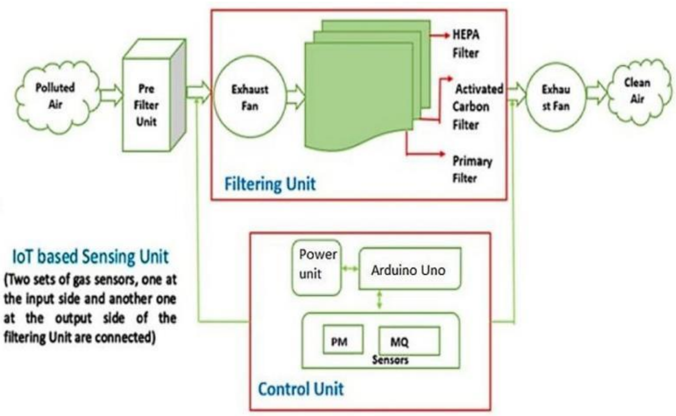


Figure. 1. Block diagram of the Air Purifier

Table 2. Components Used

S.No	COMPONENTS	DESCRIPTION
1	HEPA filters	HEPA is a type air filter can theoretically remove at least 99.97% of dust particles, pollen, mold, bacteria, and any airborne particles with a size of 0.3 microns.
2	Carbon filters	A carbon filter, often referred to as activated carbon or charcoal filter, is a type of air and water purification.
3	High speed blowers	High-speed blowers are typically used in air purifiers to ensure rapid air circulation and effective removal of airborne particles.
4	I2C	I2C (Inter-Integrated Circuit) is a serial communication protocol developed by Philips Semiconductor
5	DSM501A	It is used for quantitative particle (> 1 micron) measurements with the principle of the particle counter.
6	BME680	The BME680 is a popular sensor developed by Bosch Sensortec. It's a highly integrated environmental sensor that combines gas, humidity, temperature.
7	MQ-6	MQ-6 is a gas sensor, that has high sensitivity to butane, propane, methane
8	MQ-135	The MQ135 is a gas sensor that is commonly used for detecting various air pollutants such as ammonia, nitrogen oxides etc.
9	MQ-9	It is used for detecting LPG, CO, CH4. It makes detection by the method of cycle high and low temperature.
10	LCD	An LCD (Liquid Crystal Display) screen is an electronic display module. It contains 2 rows and 16 columns, where we can print 16 characters into one row.
11	220 to 5V Convertor	The circuit produces an output of 5V and 4A, it is mainly used in cell phone chargers, microcontrollers.
12	ESP8266	The ESP8266 is a popular Wi-Fi module developed by Espress if and embedded systems research work due to its low cost.

4. PROPOSED SOLUTION

Air pollution threatens health, making clean air crucial. To combat this, the smart air purification system employs IoT technology, integrating sensors and filters for real-time monitoring and purification. It constantly assesses air quality, adjusting purification methods accordingly. With stages like pre filters and HEPA filters, it efficiently removes contaminants. Additionally, UV sterilization eliminates harmful microorganisms. Through this multi-layered approach, it ensures fresh, breathable air indoors. Its IoT features allow remote control and monitoring, enhancing convenience. Overall, the system offers a comprehensive solution for ensuring optimal indoor air quality for health and well-being. The system's intelligent design optimizes purification processes based on sensor data, ensuring effective air cleaning. Its user-friendly interface allows easy management and enhances user experience.

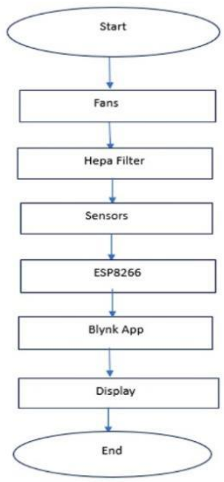


Figure. 2. Flow diagram of the Air Purifier

5. SOFTWARE USED

5.1 Arduino Uno

Arduino IDE (Integrated Development Environment) is an open-source software platform used for programming and developing applications for Arduino microcontroller boards. Here are some key features and functions of the Arduino IDE. Code Editing: The Arduino IDE provides a code editor where you can write, edit, and manage your programs. Library Support: Arduino has a vast ecosystem of libraries that simplify the development process. Board and Port Selection: Select the specific Arduino board and the communication port to which the board is connected. This allows the IDE to compile and upload code to the correct hardware.

5.2 Blynk

Blynk is a cloud-based platform and mobile app designed to facilitate the development of Internet of Things (IoT) research work, especially those involving microcontrollers like Arduino, Raspberry Pi, and others. Key features and components of the Blynk cloud platform include. Blynk App: The Blynk app, available on iOS and Android devices, allows users to create custom graphical user interfaces (GUIs).

Blynk Server: Blynk's cloud-based server acts as a bridge between your IoT devices and the mobile app.

Blynk Libraries: Blynk provides libraries and code examples for a variety of hard- ware platforms, including Arduino, Raspberry Pi, ESP8266.

Security: Blynk incorporates security measures to protect your IoT research work .

Data Widgets: Widgets include buttons, sliders, LED displays, gauges, and more.

6. IMPLEMENTATION

The filtration process is undergone in the background with the help of a High-Efficiency Particulate Air (HEPA) filter. The impurities present in air can be detected using the gas sensors and the data like temperature, humidity and air pressure can be measured and observed in the Blynk app.

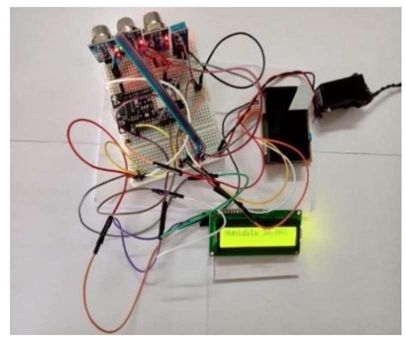


Figure. 3. Proposed System

6.1 Implementation Steps

To set up the hardware, connect the MQ-135 sensor, UV- C light module, fan, and relay module to the Arduino Uno following their respective datasheets and pin configurations. Ensure proper power supply and grounding for stable operation. For Arduino programming, develop code to read data from the MQ-135 sensor, regulate fan speed based on air quality readings, and activate the UV-C light module as needed. Integrate Blynk integration code to establish communication with the Blynk Cloud server for remote monitoring and control.

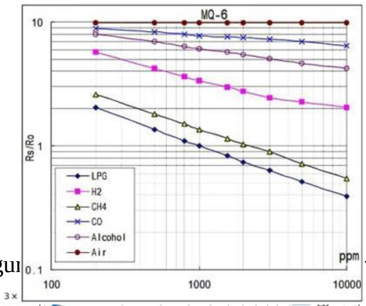
In the Blynk app, create a new project and add widgets like gauges for air quality monitoring, sliders for fan speed control, and buttons to activate UV sterilization. Obtain the authentication token for your project. Integrate the Blynk authentication token into your Arduino code and utilize Blynk library functions to transmit sensor data to the Blynk server and receive commands from the mobile app.

Test the system thoroughly to ensure functionality and calibrate the air quality sensor if required for accuracy improvement. Verify remote monitoring and control features through the Blynk app. Implement safety precautions, particularly for UV-C light, by incorporating automatic shut-off mechanisms when accessed physically or remotely to mitigate potential harm to humans and pets. Upon successful testing, finalize the hardware setup, secure connections, and consider enclosure options to safeguard the system from external elements

7. RESULTS

Air Quality Improvement: Measure the reduction in airborne particles, allergens, and odors in the room. Symptom Relief: Assess if the air purifier helps alleviate symptoms like allergies or respiratory issues. Odor Reduction: Determine if there's a noticeable decrease in unpleasant odors. Filter Replacement Frequency: Regularly replacing filters is crucial for maintaining the accuracy of the air purifier. If you notice a significant buildup of dirt and particles on the filter, it indicates that the purifier is capturing pollutants from the air. The levels of the monitored ambient air parameters are visualized. Graph: The MQ6 sensor typically shows an increase in resistance with increasing concentration of the target gas. The relationship between gas concentration and sensor resistance might not be linear. Generally, as the concentration of the target gas increases, the sensor resistance increases. These are the various graphs for MQ6, MQ135, MQ9 that represents the different pollutants that are present in the air. Graph: Similar to MQ6, MQ9 also shows an increase in resistance with increasing concentration of the target gas, particularly for CO. The relationship may not be linear. For flammable gases, the resistance might decrease with increasing concentration.

Figure. 4. User Interfacing Blynk Cloud



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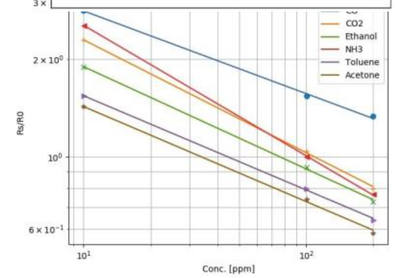

Figure. 6. Gases detected by MQ135 sensor

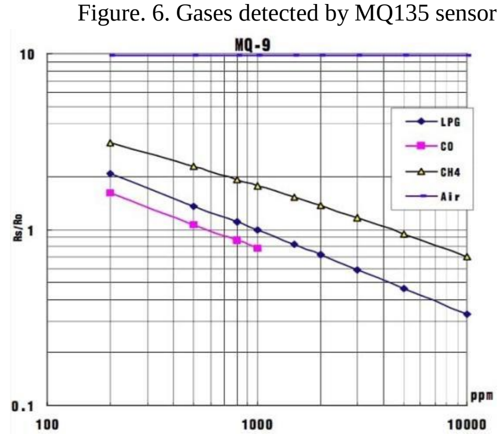

Figure. 7. Gases Detected by MQ9 Sensor

7. CONCLUSION

In conclusion, smart air purifiers represent a significant advancement in indoor air quality management, blending technology and functionality to provide cleaner and healthier environments. These devices are equipped with sophisticated sensors and connectivity features, allowing for real-time monitoring and control of air quality through mobile apps and smart home systems.

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