

IoT based Air and Noise Pollution Monitoring System

Arundathi M K¹, Feby Elza Kurian², Mary Angel John³, Navneeth Sunil Varrma⁴ and Arun P⁵

¹⁻⁵ Department of ECE, St. Joseph's College of Engineering and Technology, Palai

Email: arundathim.k2025@ec.sjcetpalai.ac.in

Email: {febyelzakurian2025, maryangeljohn2025, navneethsunilvarrma2025, arun}@ec.sjcetpalai.ac.in

Abstract—In recent years, urbanization has led to a significant increase in air and noise pollution, posing health risks and environmental concerns. Traditional methods of pollution monitoring, such as manual data collection and spot testing, are often inadequate for capturing real-time data and responding promptly to environmental changes. Hence, automated, IoT-based systems provide a more efficient solution by continuously monitoring pollution levels, analyzing data in real-time, and enabling proactive intervention. This paper proposes an approach to mitigate urban environmental challenges through the implementation of an Internet of Things (IoT) based air and noise pollution monitoring system. This integrates an ATmega328p microcontroller, utilizing MQ135, DHT11, and sound sensors to collect data on air quality, temperature, humidity, and noise levels. This data is wirelessly transmitted to an online platform Blynk via an ESP8266-01 Wi-fi module, for seamless connectivity and management. Integrated OLED displays on each sensor node provide local feedback on key pollution parameters, enhancing public awareness. People who live in cities have limited access to real-time pollution data. Once installed, the system will provide a solution for real-time monitoring of air and noise pollution, with the added benefit of remote access via physical displays and the Blynk platform. Its ease of use and low maintenance requirements make it ideal for placement in homes, schools, construction sites, traffic, and rural regions.

Index Terms—IoT, pollution monitoring, ATmega328p, sensors, wi-fi module, Blynk.

I. INTRODUCTION

The elevated concerns about air and noise pollution pose significant obstacles, especially in highly populated urban areas. Elevated air pollution has deleterious effects that go well beyond environmental degradation. It has a pervasive influence on public health sectors, aggravating respiratory diseases, cardiovascular difficulties, and even neurological disorders.

In a similar vein, the ubiquitous existence of noise pollution places a complex strain on the well-being of society, presenting itself in a number of ways, including hearing loss, social behaviour disruptions, increased levels of aggravation, and sleep patterns disruption. The severity of air quality crises has been brought to light by recent high-profile instances, particularly in Delhi and other similar places. These incidents serve as poignant reminders of the urgent need for comprehensive monitoring and mitigation efforts.

The deleterious effects of air pollution on human health are well-documented. Particulate matter, especially fine particles with a diameter of 2.5 micrometers or less, can penetrate deep into the respiratory system, causing respiratory and cardiovascular diseases. Nitrogen dioxide is known to exacerbate asthma and reduce lung function, while ozone can trigger respiratory problems and aggravate existing conditions such as bronchitis and emphysema.

Noise pollution, characterized by excessive or disruptive noise levels, has emerged as a pervasive environmental stressor in urban areas. Sources of noise pollution include traffic, industrial activities, construction sites, and recreational events. Chronic exposure to high levels of noise can lead to hearing loss, annoyance, sleep disturbances, and increased stress levels. [1].

Traditional methods of monitoring air and noise pollution typically involve stationary monitoring stations equipped with specialized instruments for measuring pollutant concentrations and noise levels. These stations are often operated by government agencies or research institutions and provide valuable data for assessing air quality and noise levels at specific locations. However, they are limited in their spatial coverage and may not capture localized variations in pollution levels.

In response to these pressing environmental challenges, the integration of microcontrollers and Internet of Things (IoT) technologies offers a promising avenue for deploying advanced monitoring systems capable of providing real-time updates on air quality and noise pollution levels. By leveraging the capabilities of IoT-enabled sensor networks, these systems can furnish users with invaluable insights into pollution dynamics, empowering them to make informed decisions and take proactive measures to mitigate the adverse effects of pollution within specific geographic locales. Through the seamless amalgamation of data acquisition, transmission, and analysis functionalities, such systems hold the potential to revolutionize the landscape of environmental monitoring, offering a holistic approach towards enhancing both public health outcomes and environmental sustainability.

II. LITERATURE REVIEW

In recent years, the integration of Internet of Things (IoT) technology into environmental monitoring systems has emerged as a promising approach to address the challenges of air and noise pollution. A significant body of research has focused on developing IoT-based solutions for real-time monitoring [2] and management of air and noise pollution in urban and industrial environments. Manglani et al. [3] introduced an IoT-based Air and Sound Pollution Monitoring System designed specifically for smart environments. Their work highlighted the potential of IoT devices and sensor networks to provide comprehensive insights into environmental conditions. This system presumably aimed to address the need for simultaneous monitoring of air quality and noise levels, essential for effective pollution control and mitigation strategies. Datta et al. [4] further contributed to the field by presenting an IoT Based Air Quality and Noise Pollution Monitoring System. Emphasizing the importance of simultaneous monitoring, their research likely underscored the significance of real-time data collection and analysis for informed decision-making. Such systems are crucial for assessing environmental conditions accurately and implementing targeted interventions to improve air and noise quality. Indoor environmental quality monitoring has also gained attention in recent research. Va'zquez-Lo'pez et al. [5] proposed an embedded system for indoor noise pollution monitoring via IoT, highlighting the need for monitoring indoor environments to ensure overall environmental quality. This focus on indoor spaces complements outdoor monitoring efforts and provides a more holistic understanding of pollution sources and exposure risks. Additionally, Kalajdjieski et al. [6] contributed to the literature with their IoT Based Framework for Air Pollution Monitoring in Smart Cities [7]. By leveraging IoT devices and sensor networks, their framework aimed to enable real-time monitoring, analysis, and decision-making for pollution control and mitigation strategies. Such comprehensive frameworks are essential for addressing complex urban pollution challenges effectively. Further enhancing the literature, several research papers have explored the design and implementation of IoT-based air pollution monitoring systems. Rushikesh et al. [8] focused on the development of an IoT-based system specifically tailored for monitoring vehicular pollution. The system integrated sensors capable of measuring pollutants emitted by vehicles, such as carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM). Data collected by these sensors are transmitted wirelessly to a central server for real-time analysis and visualization. The system aimed to provide insights into vehicular emissions, enabling authorities to take appropriate measures to mitigate pollution levels and improve air quality. Gaur et al. [9] evaluated the performance on real IoT testbed using Raspberry Pi 3 as a mobile IoT Edge Gateway for network handover decision making among various alternatives, such as Wi-Fi, Radio, and Satellite. The results demonstrated better performance compared with the native environment, i.e., the one without introduction of a virtualization layer. Oluwasanya et al. [10] presents a portable multi-sensor air quality monitoring platform designed for personal exposure studies. The system was designed to be lightweight and wearable, allowing individuals to carry it with them throughout their daily activities. Giovanni B. Fioccola et al. [11] proposed an Arduino-based air pollution monitoring system 'Polluino'. A system for monitoring the air pollution via Arduino [12]. Moreover, a Cloud-based platform that manages data coming from air quality sensors was developed. Khan et al. [13] proposed a

system that georeferenced collection, processing and analysis of traffic related pollution information around roads and its effect on the quality of life in Smart Cities. A complete solution, from physical level consisting of sensors, communication system, data management and storage on a cloud platform was presented. Rossi et al. [14] presented an environmental monitoring system based on wireless sensor network for air quality measurement and natural gas leakages [15]. The system is based on catalytic off the-self available gas sensors and on a novel strategy of sampling and processing which permits to reduce the energy consumption of one order of magnitude. The wireless sensor network developed has been also extended using a smartphone to enable data sharing over internet and to enhance portability of the overall system.

In a similar vein, numerous additional research teams have offered various workable options for an environmental monitoring system that operates in real time. A real-time air pollution monitoring system was established by Baralis et al. [16] using traffic and meteorological data gathered in Milan. The following environmental and traffic parameters were gathered from stationary monitoring sensor nodes: (i) pollutant conditions, such as ozone, sulphur dioxide, carbon monoxide, nitrogen dioxide, benzene, and particulate matter (PM) 10 and 2.5; (ii) climate conditions, such as humidity, wind speed, precipitation level, and atmospheric temperature and pressure; and (iii) traffic data. To determine the correlations between various traffic types and pollution/climate conditions, data analytics was used. A cloud-based architecture with numerous mobile or static data collecting nodes was created by Sendra et al. in [17]. Although the data was kept in local databases by the nodes, it was all integrated into a single centralized database. A collaborative decision-making and alerting system was the primary goal, and user feedback on a mobile application was also taken into account. Three levels make up the network architecture described by Jin et al. in [18]: the lowest tier is made up of both mobile and static sensors for data collection on noise pollution, middle, made up of relay nodes that gather information from sensors and forward it to gateways, and top, made up of gateways that gather information and forward it to a cloud system.

Similarly, many other research groups have suggested different feasible solutions for real-time environmental monitoring system. These studies collectively underscore the growing significance of IoT-based air and noise pollution monitoring systems in promoting environmental sustainability and public health.

The design and development of IoT based air and noise pollution monitoring system is proposed in this paper. Incorporating sensor functions by gathering data on air quality, temperature, humidity, and noise levels through sensor setup. This data is processed by the microcontroller (ATmega328P), which then transmits it to the Blynk cloud platform via a Wi-Fi module (ESP-01). On the cloud [4], the data is analyzed, trends are identified and visualizations are generated. Users can access this information through a web or mobile interface, allowing them to monitor pollution levels in real-time and receive alerts when thresholds are exceeded. Regular maintenance and calibration of sensors ensure data accuracy and reliability over time, making it an effective tool for environmental monitoring and management [19].

The rest of the paper is structured as follows: the system model and methodology are explained in Section III. The results and related discussion have been presented in Section IV followed by the conclusions and future works [20].

III. METHODOLOGY AND SYSTEM DESIGN

The circuit diagram for the system is created using the EasyEDA software. The Arduino IDE was utilized to program the development board's microprocessor, which is an ATmega328P microcontroller.

Three input parameters are employed to collect the data: the temperature and humidity are read by a DHT11 sensor, the general air quality is monitored by a MQ135 sensor, and the sound quality is monitored by an analog sound sensor.

The ATmega328p microcontroller receives data from these three sensors and processes it. [21] The resulting data is then uploaded to the Blynk IoT cloud via a wifi module ESP-01 and delivered to a live OLED display unit, enabling remote data access. The ESP-01 has a 3.3V voltage regulator because its operational voltage range is 3.3 volts, while a 5V power source powers the entire circuit. Additionally, a power-on indication and a switch are included. The detailed block diagram and circuit diagram of the system is shown in Figure 1. and Figure 2. respectively. The individual main components are explained below:

This system consists of 7 main blocks: ATmega328P, Sound sensor, Air quality sensor, Temperature & humidity sensor, Power supply, OLED, Wifi Module. The ATmega328P is a popular 8-bit microcontroller by Microchip, featuring 32KB Flash memory, 1KB EEPROM, 2KB SRAM, running at up to 20MHz. It offers 23 GPIO pins, 6 ADC channels, UART, SPI, I2C interfaces, and timers. It operates at 1.8-5.5V, with low power consumption options. The MQ135 sensor is a gas sensor widely used for detecting various air pollutants including ammonia,

nitrogen oxides, benzene, and carbon monoxide. It operates on the principle of chemiresistance, where the conductivity of its sensing material changes in the presence of different gases.

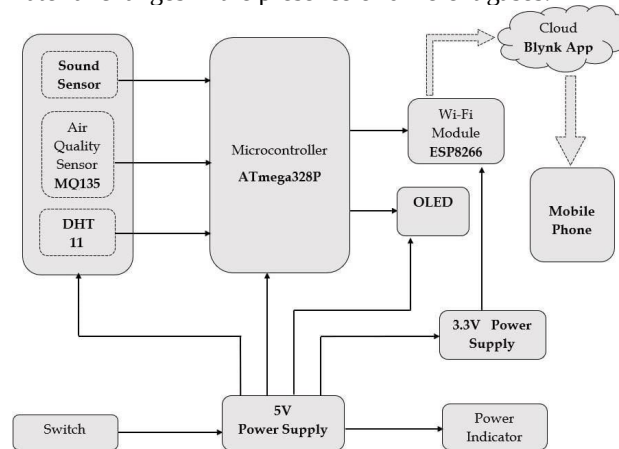


Figure 1. Block Diagram

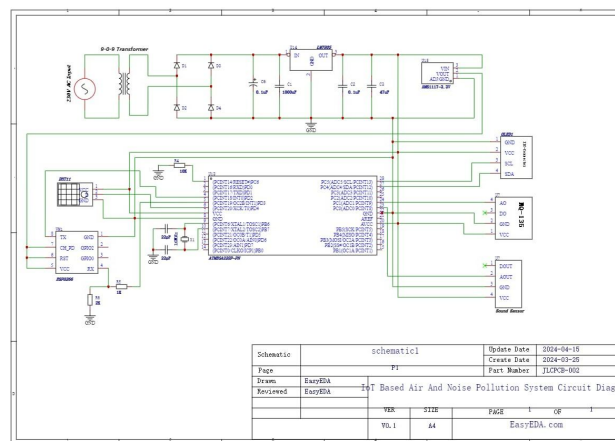


Figure 2. Circuit Diagram

This change in conductivity is then converted into an electrical signal, allowing for gas concentration measurements. Its output range typically covers gas concentrations from 10 ppm to several hundred ppm, depending on the specific gas being detected. The MQ135 gas sensor typically operates within a working voltage range of $5V \pm 0.1V$. As for current consumption, it usually requires around 150mA to 200mA during operation. The analog sound sensor detects sound levels in the environment and converts them into electrical signals, typically measured in decibels (dB). It employs a diaphragm that vibrates in response to sound waves, altering the sensor's resistance or voltage. This change is then translated into an analog signal. The sensor's output range can vary, but it generally covers a wide dB level range, from around 30 dB for quiet environments to over 100 dB for loud noises. The DHT11 sensor is a digital temperature and humidity sensor. Its function is to measure ambient temperature and humidity levels and provide digital output signals representing these measurements. It typically operates within a temperature range of 0°C to 50°C with a humidity range of 20 percent to 90 percent. The sensor utilizes a capacitive humidity sensing element and a thermistor to measure temperature. It communicates with microcontrollers using a simple digital protocol, making it easy to interface with various electronic projects. OLED (Organic Light-Emitting Diode) displays function by emitting light when an electric current is applied to organic materials between two electrodes. They produce vibrant colours, deep blacks, and high contrast ratios without a backlight. ESP-01 enables IoT (Internet of Things) applications by providing Wi-Fi connectivity for microcontroller-based projects. With GPIO pins for interfacing sensors and actuators, it allows remote monitoring and control over the internet. The ESP-01 supports TCP/IP protocols and can operate as a client or access point, facilitating communication with other devices or connecting to existing Wi-Fi networks. Its compact size and low power consumption make it suitable for a wide range of embedded applications, including home automation and sensor networks. The power supply for the circuit is provided by

the 500mA transformer. It is designed according to specifications. The 230V 50Hz AC from the power line is converted to 5V DC. A bridge rectifier is an electrical component used to convert alternating current (AC) into direct current (DC). It does this by rectifying the alternating polarity of the AC voltage, ensuring that the output voltage remains consistently positive relative to the reference point (usually ground). The main function of a bridge rectifier is to provide a steady DC voltage output from an AC input. A capacitor is an electrical component that stores and releases electricity into a circuit. It frequently sends alternating current rather than direct currents due to this it is a very important part of every electrical equipment. Electrolytic capacitors are also common components for filtering on the output of the power supply for low ripple voltage and stability. This setup incorporates two 0.1 μF capacitors, one 1000 μF capacitor, and one 47 μF capacitor. Resistors limit the flow of electric current in a circuit, converting electrical energy into heat. They control current, reduce voltage, divide voltage, and generate heat. By obeying Ohm's Law, $V=I \cdot R$, they regulate current flow, create voltage drops, and aid in circuit design for proper functionality. The LM7805 is a voltage regulator integrated circuit (IC) that provides a stable, regulated output voltage of +5 volts DC from an unregulated input voltage. Its primary function is to regulate and maintain a constant output voltage, regardless of fluctuations in the input voltage or load variations. It ensures a reliable power supply for electronic circuits and components, such as microcontrollers, sensors, and other integrated circuits, by reducing voltage fluctuations and ensuring consistent operation. The AMS1117 is a voltage regulator IC commonly used to provide a stable, regulated output voltage from a higher, unregulated input voltage. In the case of the AMS1117 3.3V variant, its function is to maintain a constant output voltage of 3.3V DC, suitable for powering various electronic components and circuits. The Wi-Fi module esp01 is powered by AMS1117. The Blynk app is a mobile application used for IoT (Internet of Things) projects. It allows users to create custom interfaces (known as widgets) to remotely monitor and control electronic devices via the internet. Users can easily connect their hardware projects to the Blynk cloud platform using supported microcontrollers like Arduino, ESP8266, or Raspberry Pi. The app provides a user-friendly interface for managing IoT projects, enabling real time data visualization, sensor readings, push notifications, and device control from anywhere in the world.

The complete process flow is given here.

STEP 1: Start the system by turning on the power supply.

STEP 2: Initialize the hardware components and other sensors.

STEP 3: ESP-01 Wi-Fi module communicates serially with Atmega328P with a baud rate of 11520.

STEP 4: Users SSID and password are given in the code for connecting the Wi-Fi module with the router.

STEP 5: Atmospheric temperature and humidity are measured using DHT11.

STEP 6: Air quality is measured using MQ135.

STEP 7: Surrounding sound quality is measured using analog sound sensor.

STEP 8: Temperature, humidity, air quality (in ppm) and sound (in dB) are displayed on OLED display.

STEP 9: The processed data is uploaded to Blynk IoT cloud using Wi-Fi module for remote accessing of data from anywhere.

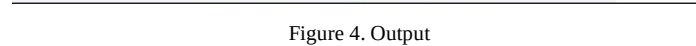
IV. RESULT AND DISCUSSION

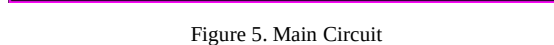
The results achieved at different phases of the project are described in this part. The key stages of developing and implementing this system are- Design simulation, output of the application and prototype. The Power Supply, MQ135 sensor, DHT11, Sound Sensor, ESP8266-01, OLED Display and AMS1117 regulator are all assembled on a breadboard following the circuit diagram. Figure 3. shows the Breadboard Level Implementation. The temperature, humidity, sound level, and air quality index values are all clearly displayed on the OLED display.

Moreover, the Blynk platform accurately transferred and presented these readings. Figure 4. shows the data analysis on the Blynk app which displays the temperature measure, humidity, sound level and air quality of the atmosphere in real-time with the help of various sensors mentioned above. If levels rise above a certain level, alert message is displayed. The information is stored in the cloud platform, and can be observed in the application. The user interface is very simple and can be understood easily. The main circuit and power supply PCB designs are presented in Figure 5. and Figure 6. In the architecture of the system integrating components such as ATmega328P microcontroller, MQ135 sensor, LM385 sound sensor, ESP8266 Wi-Fi module, and OLED display.

The ATmega328P serves as the central processing unit managing sensor data acquisition, communication protocols with the ESP8266 for Wi-Fi connectivity, and driving the OLED display for real-time data visualization. The MQ135 sensor detects various air pollutants while the LM385 sound sensor captures ambient

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Power supply PCB design incorporates components such as a 9-0-9V 500mA step-down transformer, bridge rectifier, and a 7805 voltage regulator to regulate the voltage for stable operation of the circuitry. The PCB for

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the power supply was designed with a board outline of 50 mm width and 40 mm height. The components are strategically placed to make the best use of space and minimize signal interference. The components include resistors, capacitors, diodes and ICs. The holes are designed with a diameter of 1.5 mm to accommodate the component leads and mounting screws. This design ensures reliability, efficiency, and ease of assembly for the deployment of the pollution monitoring system. After the PCB layout was designed, the copper board was printed with the layout, etched, and the required holes were drilled. Connectivity is verified and necessary routings are provided. All of the remaining parts, including the connectors, IC base, crystal oscillator, reset resistor, diode, capacitor, and LM7805, are soldered. Both the main supply PCB board and the power supply PCB board have their connections examined and their continuity confirmed. After the microcontroller and components are installed, the results were verified. The temperature, humidity, sound level, and air quality index values are all clearly displayed on the OLED display. Moreover, the Blynk platform accurately transferred and presented these readings. Figure 7. shows the PCB Implementation of project. Figure 8. shows the Top View and Side View of the project.

Real-time data on temperature, humidity, sound levels, and air quality index (AQI) were successfully given by the Internet of Things-based air and noise pollution monitoring system. Both the Blynk mobile app UI and an OLED display showed this information. Precise measurement of the Air Quality Index (AQI) is crucial in determining the extent of air pollution. Additionally, the device assessed the noise levels, which provide insight into the degree of environmental noise pollution. Understanding the effects of noise pollution on health and wellbeing requires knowledge of this data. The monitoring system also provided data on temperature and humidity. Making sure that the captured data was accurate was one of the difficulties encountered throughout development. To reduce errors, the sensors needed to be periodically maintained and calibrated. There was a problem with the Wi-Fi module. Sometimes problems with connectivity prevent data from being transmitted, which causes brief pauses in monitoring. This issue was lessened with the help of Wi-Fi network optimization and troubleshooting. One of the biggest obstacles to the system's ongoing operation was power outages. The Blynk app and the OLED display combined to create a dual output interface that enhanced usability and accessibility. When comparing the provided IoT-based air and noise pollution monitoring system with the referenced projects, several key aspects emerge. Firstly, like Manglani et al. [1], the system integrates sensors for monitoring air quality and noise levels, offering real-time data collection and analysis capabilities. However, it goes further by incorporating additional functionalities such as temperature and humidity monitoring. Secondly, akin to Datta et al. [2], the system highlights the importance of simultaneous monitoring and real-time data analysis for informed decision-making. Yet, it extends

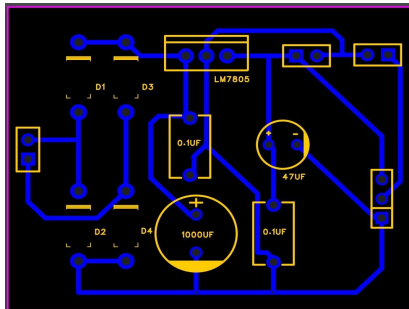


Figure 6. Power Supply

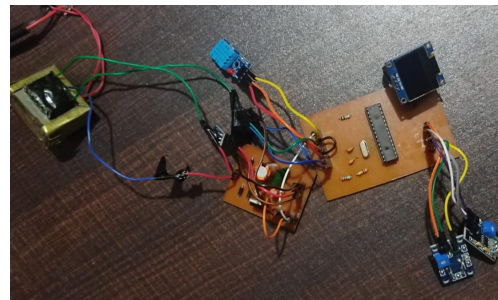


Figure 7. PCB Implementation



Figure 8. Top and side View

TABLE I. COMPARISON WITH EXISTING WORKS

Reference	Microcontroller Platform	Sensors Used	Cloud Platform
11	Arduino	MQ-2, MQ-3, MQ-4, MQ-131, MQ-7, MQ-136, MQ-137, MQ-138, MG-811, GP2Y1010AU0F, DHT11, DS18B20	ThingSpeak
13	Arduino/ATmega2560	DHT 11, MQ4, MQ135, MQ7, Keyes KY0037, GP2Y1010 F 49, HL-83	ThingSpeak
14	JN5148-001, MSP430F247	MICS-5121, TGS2610	ThingSpeak
Proposed System	ATmega 328P	MQ-135, DHT11, Sound Sensor	Blynk

beyond their focus, providing options for remote monitoring through the Blynk app and real-time visualization on an OLED display. Additionally, while Vazquez-Lopez et al. [3] focus on indoor noise pollution monitoring, the provided system offers a more comprehensive solution adaptable to both indoor and outdoor environments. Finally, like Kalajdjieski et al. [4], the system contributes to pollution monitoring efforts, especially in smart cities, with its real-time monitoring capabilities and integration with the Blynk server for seamless data transmission.

Overall, despite the challenges, the IoT-based air and noise pollution monitoring system has proven to be a valuable tool for assessing environmental quality and raising awareness of pollution levels. Further improvements and innovations can increase the effectiveness of the system in monitoring and mitigating pollution.

A comparative analysis has been conducted by taking into account the current systems. The Table I presents the details. The suggested system and other existing technologies are compared in the table based on the microcontroller utilized, the sensors integrated, and the cloud platform. This comparative analysis provides valuable insights into the strengths and weaknesses of each option, guiding the selection process for the most suitable system for specific needs and objectives.

V. CONCLUSION

In the pursuit of sustainable development and environmental conservation, IoT technology has emerged as a transformative tool. The proposed IoT-based air and noise pollution monitoring system showcases technology's potential to address environmental concerns by offering real-time insights into the surroundings through sensors measuring temperature, humidity, sound level, and air quality. Beyond the initial goals, this system empowers communities and policymakers to make informed decisions, fostering sustainable practices and proactive pollution mitigation strategies.

The proposed system integrates an ATmega328P microcontroller, utilizing DHT11 sensors for temperature and humidity, MQ-135 sensors for air quality, and sound sensors to measure noise levels. The data collected by these sensors is transmitted to an online platform, Blynk, via an ESP8266-01 module for real-time monitoring and analysis. This setup ensures that users have continuous access to critical environmental data, facilitating timely and informed responses to pollution levels. The monitoring system's scalability and adaptability are key strengths, allowing seamless integration of additional sensors and functionalities to meet evolving environmental challenges. Advancements in sensor technology and data analytics promise to enhance data accuracy, enriching the understanding of environmental dynamics. Looking forward, refining predictive analytics models and integrating AI and ML algorithms offer exciting prospects for optimizing sensor networks and enabling autonomous decision-making, further advancing the efforts to combat air and noise pollution and pave the way for a sustainable future.

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