IoT Enabled Smart Air Purifier

Dr. MOHANRAJ M, SHREE BRAMMAGIRI N, SIVANITHISH R K, ROJA K
Electrical and Electronics Engineering
Kumaraguru College of Technology
Coimbatore, India

***Abstract* - The process of waste disposal and sorting in dumping yards exposes workers to harmful airborne pollutants, leading to respiratory and health issues. This study proposes an innovative solution to address these challenges by developing an integrated system for air quality monitoring and purifying system in waste sorting facilities. The primary goal is to continuously assess the air quality within these facilities and provide real-time alerts to workers when it exceeds certain thresholds. This system utilizes a network of sensors to monitor various air quality parameters, including particulate matter, volatile organic compounds, and gases emitted during waste-related activities like incineration. Data collected from these sensors is transmitted to a cloud-based platform for storage, analysis, and future reference. By prioritizing the health and well-being of waste facility workers, this project also contributes to the long-term environmental sustainability of society. The results of this research demonstrate the feasibility and effectiveness of implementing an integrated air quality monitoring and purification system to mitigate health risks and enhance working conditions within waste sorting facilities.**
Keywords: Air quality, ESP32, PMS7003, IoT, HEPA filter, Solar Powered,Air pollution

I. INTRODUCTION

Our daily lives and activities are impacted by air pollution. It endangers both the planet's ecology and the standard of living. Due to a growth in industrial activity over the past few years, there is an urgent need to check the quality of the air [1]. When hazardous or poisonous materials, such as gasses, dust, and biological molecules, are added to the Earth's atmosphere, air pollution results. Air pollution is a recent major issue for emerging nations and is a result of the fast advancement of both industrial evolution and transportation. It is among the main problems with the atmosphere. Controlling air pollution is necessary to prevent deadly illnesses that affect people, such as cancer, respiratory disorders, and many others. Air quality sensors and a Node MCU are used in the design of the air pollution monitoring system. These hardware elements are used in the automation process to facilitate wireless communication and regulate sensor behavior. Sensors like air quality, gas, temperature, and humidity are all under the control of the Node Microcontroller Unit. Every sensor receives signals from Node MCU instructing it to carry out a certain task or retrieve data from a particular sensor. The ThingSpeak cloud receives the data transmitted from the microcontroller [2]. These days, the Internet of Things (IoT) is being used extensively in every industry, and it is also essential to our system for monitoring air quality. To make it easy for us to monitor, our setup will display the air quality in PPM (Parts per Million) on a webpage. With this IoT project, anyone may use a PC or a mobile device to monitor the pollution level from anywhere [3]. A number of elements, including the economy, high-quality education, agriculture, industries, and many more, are necessary for the globe to grow sustainably, but the environment is one of the most crucial ones.

The advancement of any nation and the sustainability of humankind both depend on good health and hygiene, which are products of a safe, hazardous-free environment. Therefore, it becomes imperative to monitor it to guarantee that every country's population may live healthy lives[5]. Addressing the safety of waste separation workers, this project offers a vital solution through alert signals triggered when threshold levels are reached. Tailored to the specific needs of individuals working in waste separation yards, the system ensures timely warnings about atmospheric pollutant levels. The integration of alert signals enhances the overall safety measures, creating a proactive and responsive environment for workers. By focusing on real-time monitoring and immediate alerts, the project aims to significantly reduce health risks and improve the overall well-being of those employed in waste separation activities.

II. LITERATURE SURVEY

The system under review, built on the Arduino microcontroller platform, is designed to perform real-time monitoring and analysis of air pollution. It incorporates an MQ135 sensor for quantifying air quality,the results will be displayed on an LCD screen. A notable feature of this system is its capacity to send data to a remote server via a Wi-Fi module, utilizing the "ThingSpeak" platform, thereby enabling access to real-time air quality data on a global scale. This system offers not only immediate data visualization but also serves as a tool for promoting awareness of air quality, making it an asset for environmental monitoring and public health, with opportunities for further advancement in future research and development.

Air pollution, a result of industrial and transportation growth, particularly impacting developing nations, poses severe health risks. A wireless, automated solution is provided by an air pollution monitoring system that uses an air quality sensor and a Node MCU. It monitors pollutants in areas with waste accumulation, contributing to air pollution. The system is cost-effective for integration into existing infrastructures, comprehensively monitoring CO2, Smoke, LPG, Temperature, Humidity, SO2, NO2, and Alcohol. Data is sent to the ThingSpeak cloud platform, which aids in real-time pollution data visualization through a mobile app and enables cloud-based analysis for identifying pollution sources and implementing preventive measures.

Air pollution, driven by industrial emissions, vehicle exhaust, and urbanization, poses significant health risks. Real-time air quality monitoring is crucial for informed decision-making, and the paper introduces a standalone system with Internet of Things (IoT) integration. Data on air quality is shown on a webpage in Parts per Million (PPM), making it accessible from a variety of devices. Challenges related to vehicle emissions and pollution intensity are discussed, along with IoT's role in data transmission and remote access. Visualizations of air quality data and Linear Regression for data analysis are presented. The paper highlights the use of MQ135 and MQ7 sensors to detect specific gases and addresses indoor and outdoor monitoring using sensor networks. It emphasizes the importance of sensor calibration and the potential for applying machine learning techniques in data analysis for improved air quality.

III. PROBLEM STATEMENT

Workers involved in waste segregation face a significant challenge due to pollution stemming from waste incineration, which threatens their health and well-being. The emissions produced during incineration processes present health risks, thereby creating an unsafe working environment. These pollutants not only degrade air quality, adversely affecting the respiratory health of workers, but also pose potential long-term health hazards. It is imperative to address this issue to protect workers' health and maintain a sustainable waste management process. Dealing with pollution challenges necessitates implementing strategic measures to improve workplace safety, ultimately fostering a healthier environment for individuals engaged in waste segregation activities.

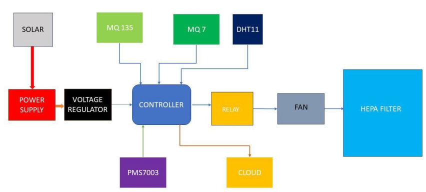

Fig.1. Proposed block diagram

Fig. 1 represents the proposed block diagram for simulation. Within waste segregation environments, workers frequently confront health challenges due to heightened pollution resulting from waste incineration processes and the release of gases from waste materials. In response to this critical issue, we've developed an innovative portable air quality monitoring and purifying system. This device integrates essential sensors, including the PMS3007 for particulate matter monitoring, the DHT11 for tracking temperature and humidity, as well as gas sensors MQ135 and MQ7. Additionally, it features an efficient solar-powered portable purification system equipped with a HEPA filter.

This system's primary goal is to proactively address the health concerns that employees in waste segregation facilities face. The integrated sensors collaborate to assess air quality parameters, ensuring a comprehensive evaluation of the surrounding environment. Employing a HEPA filter, the portable purification system effectively filters dust particles, providing a proven method for maintaining air quality. Moreover, the device is designed to issue notifications via a mobile application when air quality levels exceed predefined thresholds. This real-time alert system serves as a crucial tool, offering timely notifications to workers and enabling them to stay informed about prevailing air quality conditions.

1. MQ 135

Fig.2 MQ 135 sensor

In Figure 2, we observe the MQ-135 Gas sensor, specifically engineered for applications in air quality control. A wide range of gases, including NH3, NOx, alcohol, benzene, smoke, and CO2, can be detected and measured by this sensor. Interestingly, the sensor module has a Digital Pin, which allows it to function independently without a microcontroller. This is useful for activities involving the detection of a single gas. For PPM measurements, the analog pin, TTL driven, and compatible with 5V, is utilized, rendering it compatible with most standard microcontrollers. The MQ-135 sensor is a useful and dependable option if your application requires a sensor that can identify common air quality gases like CO2, smoke, NH3, NOx, alcohol, and benzene.

2. MQ-7 GAS SENSOR

Fig.3 MQ-7 sensor

The MQ-7 Semiconductor Sensor depicted in Figure 3 is specifically designed for Carbon Monoxide detection, utilizing a sensitive material, SnO2, with reduced conductivity in clean air conditions. Using a temperature cycling method, it exhibits enhanced conductivity as the concentration of gas rises and detects CO at a low temperature (heated by 1.5V). It efficiently removes gases that have been adsorbed during low-temperature operations at a high temperature (heated by 5.0V). By integrating a simple circuit, the variation in conductivity is translated into an output signal indicative of gas concentration. Renowned for its remarkable sensitivity to Carbon Monoxide, the MQ-7 sensor offers a cost-effective solution suitable for a wide array of applications, capable of detecting various gases containing CO. The sensor's performance hinges on the chemiresistor, Tin Dioxide (SnO2), characterized by free electrons that interact with oxygen molecules, consequently influencing output current based on the availability of free electrons in SnO2.

3. ESP32 microcontroller:

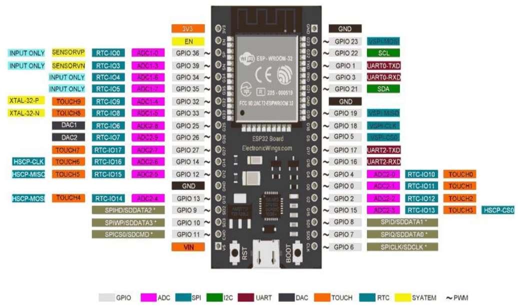

Fig.4 ESP32 Microcontroller

The ESP32 is the primary controller in our research project. It offers strong performance and flexibility. The ESP32 has a dual core processor and integrates Wi-Fi & Bluetooth. This makes for smooth connection and efficient processing. We can use the ESP32 to implement complicated algorithms and manage real time data processing tasks efficiently. The low power consumption combined with the large number of GPIO pins makes it suitable for this application. This allows us to scale up and down in our project while keeping the reliability and performance of the ESP32 in mind. Using the ESP32 gives us the ability to create innovative solutions.

4. HEPA Filter

Fig.5 HEPA Filter

HEPA filter in the above fig which stands for "High Efficiency Particulate Absorption," represents a well-established and highly reliable technology utilized for filtering air particles within indoor environments for many years. HEPA filter-equipped air purifiers are remarkably effective at capturing up to 99.97% of airborne particles, which include dust, pollen, allergens, and other particles with a size of 0.3 microns or more [9]. The conventional unit of measurement for air particles is microns; particles larger than 10 microns are observable to the unaided eye. Consequently, particles such as chemicals, bacteria, and viruses trapped by a HEPA filter remain imperceptible. HEPA filter air purifiers typically have a fan that pulls air through a filter medium made up of complex layers of thin fiber sheets. Mold and bacteria are successfully captured by the filter's first layer, which promotes a more hygienic atmosphere. Then, to achieve maximum efficiency, the secondary layer is made up of boron silicate microfibers that have been painstakingly layered into a flat sheet structure. The dense construction of a HEPA filter results from numerous filter sheets being stacked and folded in a zigzag formation, maximizing the surface area within a confined space.

5. PMS7003 Particulate matter sensor

Fig.6 PMS7003 Particulate matter sensor

The PMS7003 in Figure 6 above is a digital and flexible particle concentration sensor designed to measure the number of suspended particles in the atmosphere. It is shown in Figure 6 above. Its capability to deliver particle concentration data via a digital interface renders it suitable for incorporation into a range of instruments pertaining to air particle concentration or devices aimed at environmental enhancement. This sensor guarantees real-time and precise concentration data, thereby facilitating efficient monitoring and improvement of air quality.

6. DHT11 sensor

Fig.7 DHT11 sensor

The DHT11 sensor depicted in Figure 7 acts as a cost-effective digital sensor specifically crafted for temperature and humidity sensing. It seamlessly integrates with a range of microcontrollers, such as Arduino and Raspberry Pi, facilitating instant measurement of humidity and temperature. Both sensor and module versions are available; the module version adds features such a power-on LED and a pull-up resistor. The DHT11, which functions mainly as a relative humidity sensor, combines a capacitive humidity sensor with a thermistor to deliver accurate readings of the ambient air quality.

VI. WORKING

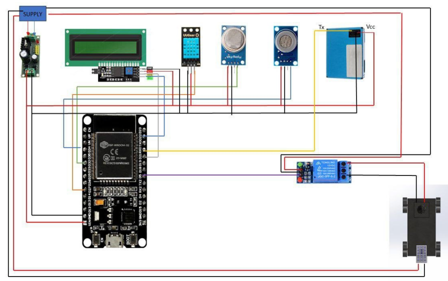

Fig.8 Circuit Diagram

Fig.8 illustrates our proposed work, which incorporates a group of gas sensors including MQ-7 and MQ-135, along with the DHT11 sensor for temperature and humidity sensing. Additionally, the Plantpower7003 PMS sensor is utilized for detecting PM1.0, PM2.5, and PM10 particles. The ESP32 serves as the primary controller for this setup. Connecting the LCD module to the ESP32 is facilitated via an I2C module, using only 4 pins. The ESP32 microcontroller is programmed to collect sensor data, which is then shared with a cloud platform and displayed in percentage format. The cloud platform provides a graphical user interface for visualizing sensor data at specific intervals. If any sensor data exceeds predefined threshold values, the microcontroller triggers the purifying system.

These sensors monitor several air quality factors, such as smoke, ammonia, sulfur, CO_2, benzene, particulate matter, and carbon monoxide. The ESP32 receives and processes sensor data before transmitting it to the cloud server. The entire system is powered by a solar panel and a battery, enhancing its efficiency and sustainability.

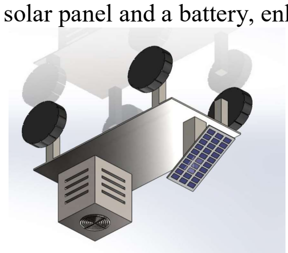

Fig.9 Mechanical design of proposed system

The tapered intake in the filter body traps the air inside once it is drawn through the opening in the back of the system. The duct disperses the air throughout the surface while the holes' increased air speed and pressure cause a region of suction [11]. Upon entering the HEPA filter, air can capture 99.97% of particles larger than 0.3 microns.

Many minuscule bacterial species are invisible because particles smaller than 10 microns are invisible to the human eye. It eliminates smaller allergens as a result. After purification, the air is propelled upwards through an extended duct, swiftly passing through the exhaust fan located at the system's highest point. The extended duct serves a dual purpose: directing the air back into the room and mitigating turbulent forces. Through the integration of this monitoring and purification system, our objective is to equip waste segregation workers with the necessary information to safeguard their health. The portable nature of the system facilitates convenient transportation to crucial areas when pollution levels escalate. In essence, this initiative seeks to markedly enhance the general welfare of workers engaged in waste segregation endeavors by offering a proactive and responsive resolution to the issues raised by increased air pollution levels.

VII. RESULTS AND DISCUSSIONS

Fig.10 Implementation of hardware

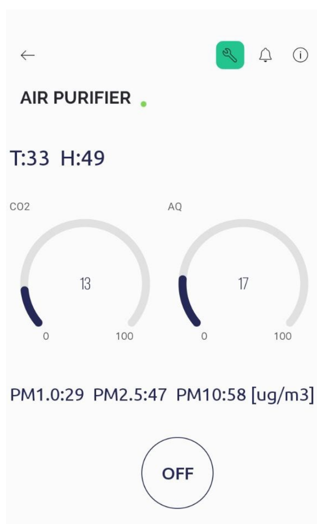

Fig.11 IoT Dashboard

The IoT-enabled smart air purifier, developed as part of our project, assesses the Air Quality Index (AQI), carbon monoxide (CO) pollution, and dust pollution by utilizing sensors such as MQ135, MQ7, and PMS7003 in the surrounding environment. Furthermore, it measures temperature and humidity levels. The captured air undergoes filtration through a HEPA filter to eliminate pollutants. The ESP32 microcontroller establishes connectivity to Wi-Fi, facilitating data transmission to an IoT platform. A dashboard accessible via a cloud-based platform enables users to operate the system remotely using their mobile phones.

VIII. CONCLUSION

In summary, the solar-powered, portable, and efficient filtration system, incorporating the ESP32 microcontroller, MQ135, DHT11, MQ7, and PMS sensors, prioritizes the well-being of workers in waste separation environments. It proactively issues alerts when air pollutant levels surpass predefined thresholds, with the DHT11 sensor offering comprehensive insights into temperature and humidity. Specialized sensors detect methane, monitor carbon monoxide, and measure particulate matter, ensuring compliance with occupational health standards. The inclusion of a portable filtration system utilizing HEPA technology provides an added advantage. This comprehensive approach mitigates respiratory risks and fosters a safer work environment. Real-time monitoring enhances efficiency, rendering it a valuable tool for advancing health and safety practices in waste management.

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