IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue 2, June 2023

Enhancing Mining Industry Safety and Air Quality Through IoT-Based Monitoring and Air Purification System

A. Ananth Chaitanya[1], P. Rahul[2], A. Siddhartha[3], Dr. D. Mohan[4]

Student, Department of Electronics and Computer Engineering[1,2,3]

Head of Department, Department of Electronics and Computer Engineering[4]

Sreenidhi Institute of Science and Technology, Hyderabad, India

Abstract: *The mining industry is very concerned about industrial safety. For workers to be safe and productive, communication and healthcare are essential. To monitor and react to potential dangers, reliable communication is essential, while medical personal protective equipment and examinations are crucial. The mining industry has to improve safety measures because the existing safety systems have flaws. To minimize dangers and safeguard workers, the mining industry uses safety systems like ventilation, emergency response plans, and gas monitoring. Fresh air is provided via ventilation, dangerous gasses are detected by gas monitoring, and accidents are reduced by emergency action procedures. These systems have drawbacks, including the inability to detect all gasses, insufficient airflow, and a limited ability to reduce accidents. Therefore, these systems need to be improved. By enhancing communication and utilizing the IoT (Internet of Things) to monitor air quality, toxicity, and workers' vital signs, our solution increases safety in the mining industry. Real-time monitoring and reporting of dangers is made possible via sensors, an esp32 board, and the blynk software. Monitoring vital signs ensures workers' health, while the method seeks to raise productivity in the mining sector. Our suggested system significantly contributes to improving safety in the mining industry by utilizing cutting-edge technology and creative solutions.*

Keywords: ESP32, Air quality detection, Air purifier, Blynk, IoT

I. INTRODUCTION

The mining industry is very concerned about industrial safety. For workers to be safe and productive, communication and healthcare are essential. To monitor and react to potential dangers, reliable communication is essential, while medical personal protective equipment and examinations are crucial. The mining industry has to improve safety measures because the existing safety systems have flaws. To minimize dangers and safeguard workers, the mining industry uses safety systems like ventilation, emergency response plans, and gas monitoring. Fresh air is provided via ventilation, dangerous gasses are detected by gas monitoring, and accidents are reduced by emergency action procedures. These systems have drawbacks, including the inability to detect all gasses, insufficient airflow, and a limited ability to reduce accidents. Therefore, these systems need to be improved. By enhancing communication and utilizing the IoT (Internet of Things) to monitor air quality, toxicity, and workers' vital signs, our solution increases safety in the mining industry. Real-time monitoring and reporting of dangers is made possible via sensors, an esp32 board, and the blynk software. Monitoring vital signs ensures workers' health, while the method seeks to raise productivity in the mining sector. Our suggested system significantly contributes to improving safety in the mining industry by utilizing cutting-edge technology and creative solutions. Introduction The mining industry is significant to the global economy because it supplies numerous industries with the raw minerals they need. However, there are other substantial dangers and hazards that are connected to mining that could have a negative impact on the health and safety of workers. Therefore, it is essential to take action to reduce these hazards and guarantee the safety and productivity of employees. The use of safety measures including gas monitoring, ventilation, and emergency response plans is one of the main ways to increase safety in mining operations. Although these solutions have some effectiveness, there are several issues that need to be resolved. For instance, faulty ventilation systems can result in poor air quality and gas monitoring systems that can only detect specific gasses can have a severe influence on worker health. Our proposal suggests a remedy that uses the Internet of Things (IoT) to improve communication and monitoring in mining operations in order to address these restrictions. Our system provides real-time monitoring and reporting of dangers, such as air quality, toxin levels, and workers' vital signs. It does this using sensors, an esp32 board, and the blynk software. By using IoT technology, our system can detect potential hazards early, allowing for a more proactive approach to safety and the implementation of preventive measures. The proposed system has the potential to revolutionize the mining industry by providing a safer and more efficient working environment for miners. Our solution can safeguard employees from danger and boost productivity by utilizing technology to improve communication and monitor possible hazards in real-time. For instance, the system can notify managers to give workers timely support and relaxation if their vital indicators suggest they are tired or uncomfortable. Our solution can also assist mining businesses in adhering to rules regarding worker safety and environmental preservation. Our approach can assist businesses in maintaining compliance and avoiding potential fines by offering thorough monitoring of air quality and toxin levels. Although the mining industry is essential for global economic development, it also poses significant risks to worker safety and health. In order to increase communication and monitoring in mining operations, our study suggests a solution that makes use of IoT technology. Our solution seeks to safeguard workers 'welfare, improve safety, and increase productivity in the mining industry by providing real-time monitoring and reporting of dangers. We consider our proposed system may significantly improve safety in the mining industry by utilizing cutting-edge technology and creative methods. Our suggested solution can offer the mining industry other benefits in addition to the gains in safety and production. For instance, our system can gather a lot of information about the health of the workforce, the surroundings, and equipment performance. Using this information, prediction models that can see possible problems before they emerge can be created. This strategy can save downtime, boost efficiency, and prolong the life of the equipment. Additionally, mining companies can use the information gathered by our technology to enhance their entire safety culture. Mining businesses can take proactive steps to enhance safety conditions and lower the frequency of accidents by analyzing the data and spotting trends. Additionally, by sharing this data across the sector, businesses may benefit from one another's expertise and best practices, making the mining sector safer and more productive. The scalability of our suggested approach is another benefit. Any size of mining operation, from small-scale enterprises to large-scale mines, can use the system. Our solution can assist mining businesses in adhering to safety standards and avoiding potential fines by providing thorough monitoring and reporting of dangers. The price of implementing our technology could be a problem. However, we think that our system's long-term advantages surpass its initial cost. By offering early identification and prevention of possible hazards, our technology can assist lower the expenses associated with accidents, downtime, and equipment failure. We advise mining businesses to work with technology vendors and safety specialists to ensure the successful adoption of our system. This cooperation can aid in ensuring that the system is customized to each company's operations and fulfills the unique needs of the mining industry. Collaboration can also assist guarantee that the solution is seamlessly integrated into current safety routines and systems. In a nutshell, our proposal suggests a method for enhancing communication and monitoring in mining operations using IoT technology. Our solution seeks to safeguard workers' welfare, improve safety, and increase productivity in the mining industry by providing real-time monitoring and reporting of dangers. Through the provision of a safer and more productive working environment for miners, our suggested technology has the potential to completely transform the mining industry. Our solution can assist create predictive models, enhance safety culture, and boost productivity by gathering a lot of data. Additionally, our suggested solution is scalable and may be used in all sizes of mining operations. We think that our suggested solution may significantly improve safety in the mining industry with the help of mining firms and technology providers.

II. LITERATURE SURVEY

A In 2016, Huang Mengtao and Feng Zunxiang proposed an exhaust gas purification system based on electrostatic adsorption. The system aims to purify the exhaust gas by capturing harmful pollutants through electrostatic adsorption, which can help to reduce air pollution levels.[1]

In 2018, Kennedy Okokpujie and Etinosa Noma-Osaghae proposed a smart air pollution monitoring system that constantly keeps track of air quality in an area and displays the air quality measured on an LCD screen. This system aims to raise awareness about air pollution and provide real-time information on air quality levels.[2]
In 2019, Ms. S. Menaga and Ms. J. Paruvathavardhini proposed an air quality monitoring system using vehicles based on IoT technology. The system has the ability to monitor the air pollution of any required area by fitting a module in a moving vehicle. This system aims to provide a comprehensive view of air pollution levels in different areas.[3]
In 2020, Farih Bin Deraman and Asrudin Bin Mat Ali proposed an innovation of an air quality detector in a passenger car using IoT technology. The system has a power window system that can be controlled automatically. This system detects high levels of CO2 in a car and actuates the power window to roll down automatically. When the CO2 levels in the car are back to a safe level, the window closes automatically. This system aims to provide a safe and comfortable driving experience.[4]
In 2021, Xue Dong proposed a design of a filtering car air purifier that can effectively improve harmful substances such as formaldehyde in a car. This system aims to provide a healthier environment for drivers and passengers in the car.[5]
In 2022 Jacquline Waworundeng ,Priana Sari Adrian proposed the Air Quality Monitoring and Detection System in vehicle Cabin Based on Internet of Things which is air quality monitoring and detection system, implemented in the vehicle cabin to raise awareness and help humans to monitor the air quality.[6]
Overall, these proposals demonstrate the efforts being made to tackle air pollution, and the diverse approaches being taken to address this global problem.

III. PROPOSED SYSTEM AND MODEL

The sensors possess the ability to identify various gas concentrations, encompassing methane, propane, hexane, ammonia, and carbon monoxide, alongside particulate matter, such as smoke and fine dust, in the proximity of the miner. The ESP-32 microcontroller is assigned a threshold value, and when this value is surpassed, an alarm is triggered. This alarm serves as a prompt for the mine worker to wear the mask that has been provided. The process of purifying the surrounding air is initiated by the air filtration system, which then propels the decontaminated air into the respiratory mask. The LCD (Liquid crystal display) integrated into the system will exhibit the detected gas values for all gasses. The same values will also be accessible through the blynk application. The removal of the mask by the worker is contingent upon a reduction in the concentration of pollutants. In the event of a requirement, the miner is provided with a source of oxygen through the oxygen tank situated within the backpack.

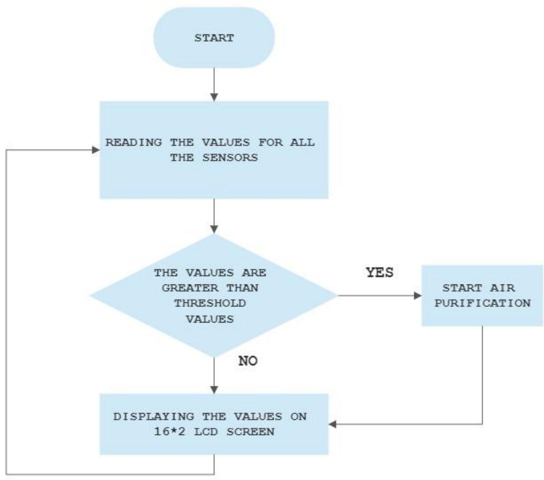

Fig 1 Workflow

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue 2, June 2023

IV. FRAMEWORK

A. MQ-2 Sensor

The MQ-2 smoke sensor is a gas sensor module that is frequently employed in fire detection and prevention systems. the device is capable of detecting various gasses, including smoke, propane, methane, carbon-di-oxide, LPG (Liquified Petroleum Gas) and alcohol, through the measurement of resistance changes that arise upon interaction between the sensing element and the gas in question. The sensor functions within a DC voltage range of 5V to 24V and is capable of detecting smoke within a range of 300 to 10,000 ppm, as well as other gasses within a range of 100 to 10,000 ppm. The MQ-2 sensor module exhibits a response time of approximately 10 seconds and a recovery time of roughly 30 seconds. It can be conveniently integrated with microcontrollers to develop smoke detection systems for the Internet of Things (IoT). [7]

B. MQ-3 Sensor

The MQ-3 sensor is a gas sensor used for the detection of volatile organic compounds, including but not limited to hexane, benzene, and methane. The MQ-3 sensor's sensing element is composed of a semiconductor material known as tin oxide (SnO_2), which exhibits a variation in its electrical resistance upon exposure to the gasses of interest. The sensing component is situated within a confined enclosure that is equipped with electrodes. Upon the application of a voltage across the electrodes, the sensing component's resistance undergoes a modification in reaction to the gasses being targeted. The MQ-3 sensor functions at a voltage of 5 volts and exhibits a power consumption of around 150 mill amperes. The sensor demonstrates a response time of less than 10 seconds and a recovery time of less than 30 seconds.[7]

C. MQ-7 Sensor

The MQ-7 sensor is a gas sensor used to detect the presence of carbon monoxide (CO) in the atmosphere. The device in question is a cost-efficient and space saving apparatus that functions through the mechanism of chemical adsorption. The MQ-7 sensor's sensing element is enveloped with a catalyst. Upon encountering the sensing element, CO molecules undergo oxidation, leading to a reduction in the resistance of the sensor. This change in resistance is subsequently translated into an electrical signal by the circuitry of the sensor. This sensor displays a notable level of sensitivity and has the capability to detect concentrations of CO as low as 20 ppm. The MQ-7 sensor's diminutive form factor and minimal energy consumption render it an optimal candidate for assimilation into diverse safety and surveillance systems.[7]

D. MQ-135 Sensor

The MQ-135 sensor is a gas sensor utilized for the detection of various gasses, such as ammonia, nitrogen oxides, benzene, smoke, and CO_2. The operational mechanism of the device is predicated upon the alteration in resistance of a sensing component upon exposure to a particular gas. The sensing apparatus comprises a diminutive heating component that elevates the temperature of the sensing element, and an electrical circuit that gauges the alterations in resistance. The sensitivity range of the MQ-135 sensor is reported to be 1 to 50 ppm for nitrogen dioxide, 10 to 300 ppm for benzene, and 100 to 10000 ppm for carbon dioxide. The device functions at a voltage of 5 volts and exhibits a power consumption of 800 mill watts. The sensor exhibits a response time of under 10 seconds and a recovery time of under 60 seconds. The compact dimensions of this entity facilitate its seamless integration into diverse systems and devices.[7]

E. DHT11 Sensor

This is a digital device that has been specifically engineered to gauge the temperature and humidity levels present in the surrounding environment. The device is composed of a capacitive humidity sensor and a thermistor, which are utilized to identify variations in relative humidity and temperature, correspondingly. This

sensor functions within a voltage range of 3.5V to 5.5V and has the capacity to gauge humidity levels between 20 percent to 90 percent with a precision of ±5 percent. The device is capable of measuring temperature within the range

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 2, June 2023

of 0°C to 50°C, exhibiting a precision of ±2°C. The data collected by the sensor is transmitted in a digital signal format through a single wire. This signal is then interpreted and analyzed by a microcontroller or other computing device.[8]

F. Pulse oxy sensor

A pulse oxy sensor is situated on a patient's finger, earlobe, or another suitable location. The sensor emits dual wavelengths of light, specifically red and infrared, that are assimilated by oxygenated and deoxygenated hemoglobin present in the blood. Unabsorbed light by hemoglobin traverses through the tissue and is perceived by the sensor. The microprocessor of the sensor examines the data on light absorption and computes the values for SpO2 and pulse rate. The circuitry of the sensor generally comprises a light source, photo detectors, and an electronic circuit that amplifies and filters the signal. It is a commonly employed medical device in various healthcare settings, including hospitals, clinics, and ambulances, for the purpose of monitoring patients afflicted with respiratory and cardiovascular ailments. Furthermore, contemporary wearable technologies integrate pulse oximetry sensors to track physical fitness and sleep-related parameters.[9]

G. HEPA Filter

HEPA filters are a type of air filtration system that is designed to effectively eliminate airborne particles and pollutants from the surrounding environment. HEPA filters are extensively utilized in diverse settings such as residential dwellings, workplaces, and healthcare centers. Air purifiers, howover cleaners and HVAC systems are frequently equipped with them in residential settings. Within medical settings, clean rooms, operating rooms, and isolation rooms employ them as a means of mitigating the transmission of contagious illnesses. HEPA filters are evaluated according to their efficacy in eliminating particles from the atmosphere. In order to meet the criteria for a genuine HEPA filter, it is necessary for the filter to eliminate a minimum of 99.97 percent of particles that possess a size of 0.3 microns or greater. Certain High Efficiency Particulate Air (HEPA) filters are capable of eliminating particles that are smaller in size, such as ultrafine particles that measure less than 0.1 microns.[10]

H. Activated carbon filter

These filters are widely used to purify air by removing impurities and harmful contaminants. The filters are composed of activated carbon, a form of carbon that has undergone oxygen treatment to produce a considerably porous substance with an extensive surface area. The filter has the capability to be tailored towards particular categories of impurities, for instance, volatile organic compounds (VOCs), chlorine, and other chemical substances. These filters are frequently employed in air purifying devices, water treatment systems, and facial masks as a means of safeguarding against hazardous contaminants. These entities exhibit a high degree of efficacy in eliminating various types of odors, including those emanating from cigarette smoke or cooking activities, within the atmosphere. [11]

I. ESP32 Board

The ESP32 board is a microcontroller development board that is extensively utilized for Internet of Things (IoT) applications due to its robustness. The device is founded on the ESP32 microcontroller, which encompasses two central processing units and provides compatibility with both Wi-Fi and Bluetooth communication protocols. The ESP32 board is endowed with a diverse array of functionalities, including but not limited to GPIO (General purpose input/output) pins, ADC (Analog to digital convertor), DAC (Digital to analog convertor), SPI (Serial peripheral interface) , I2C (Inter integrated controller), UART (Universal asynchronous receiver/ transmitter), among others, rendering it a suitable choice for a multitude of undertakings. The device's suitability for IoT applications is attributed to its diminutive size, energy efficiency, and capacity to function on battery power. [12]

J. Blynk Software

Blynk is a software application that facilitates remote control of Internet of Things (IoT) devices through both mobile and web platforms. The software enables users to create personalized and dynamic graphical user interfaces (GUI) without necessitating any programming expertise. Blynk provides an extensive selection of widgets, such as buttons, sliders, graphs, and displays, that can be conveniently placed onto a digital canvas through a drag-and-drop interface.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 2, June 2023

Blynk libraries are available for popular platforms such as Arduino, Raspberry Pi, ESP32, and NodeMCU, enabling users to establish a connection between their IoT devices and Blynk. Blynk offers cloud connectivity and secure communication protocols to safeguard user data. [13]

*K. 16*2 LCD Display*

The 162 LCD display is a frequently employed electronic display module consisting of 16 columns and 2 rows of characters, enabling the presentation of a maximum of 32 characters at any given time. Alphanumeric displays are commonly employed in diverse applications, including but not limited to digital clocks, thermometers, and home automation systems, as they are capable of exhibiting both alphabetical and numerical characters. The management of the display is facilitated by a microcontroller, which transmits signals to the display module, thereby enabling the exchange of data input and output. The 162 LCD display is a frequently selected option for electronic projects that necessitate fundamental display capabilities due to its modest interface and low power consumption.[14]

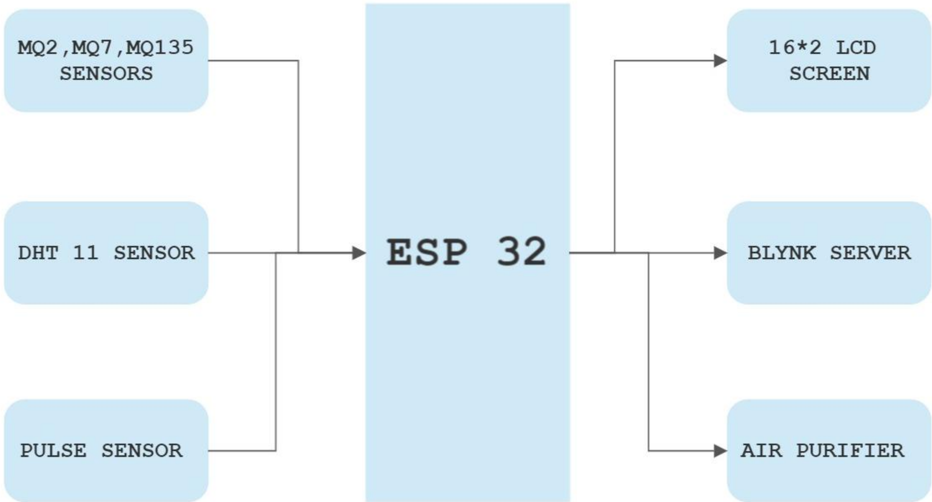

Fig 2 Block Diagram

V. MODEL DESIGN

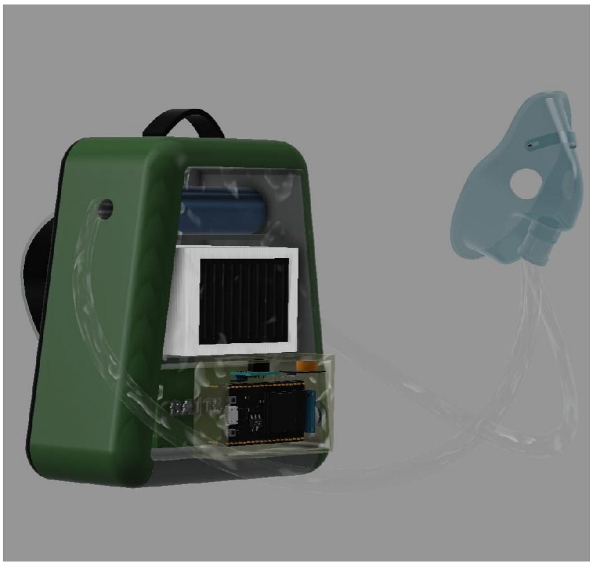

Fig 3 CAD Model

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue 2, June 2023

Here the CAD Model depicts the planned setup for the air quality detection and purification system. The main circuit along with air purifier, oxygen cylinder and respiratory mask will be installed in a backpack which can be easily worn by mine worker. Necessary alarm and communication system will also be present inside the bag

Fig 3 Metrics Display

The efficacy of the selected sensors, specifically the MQ-series gas sensors, in identifying atmospheric contaminants is demonstrated by the favorable performance of the proposed system. The sensors possess exceptional sensitivity and precision, rendering them well-suited for scenarios that demand meticulous air quality monitoring. The amalgamation of the ESP32 microcontroller and the Blynk software offers a proficient and user-centric platform for remotely managing the system and acquiring real-time data. In addition, the 16x2 Liquid Crystal Display (LCD) functions as a dependable and economical approach for presenting information, thereby facilitating comprehension and examination. The display's interface is designed to be straightforward and user-friendly, enabling users to promptly and effortlessly detect pollutant levels and implement appropriate remedial actions. The system's successful operation showcases the potential of employing sophisticated sensor technologies and IoT platforms to develop efficient air quality monitoring systems. The rising apprehensions regarding air pollution and its repercussions on human health and the ecosystem have accentuated the significance and indispensability of such systems in advocating for air quality that is both cleaner and safer.

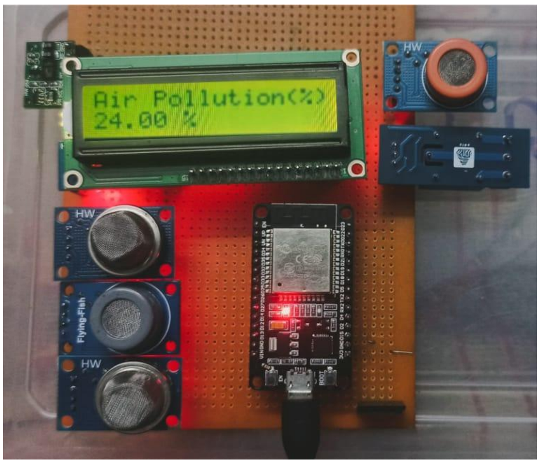

Fig 4 Output

VII. CONCLUSION

The utilization of MQ sensors and ESP32 board in conjunction with Blynk software for air quality monitoring presents a dependable and economical approach to identifying the levels of diverse atmospheric contaminants. Ultimately, this method offers a viable solution to the problem at hand. The system employs a variety of sensors to identify diverse categories of pollutants, such as carbon monoxide, nitrogen dioxide etcetera. The data obtained from the sensors is exhibited on both an LCD screen and the Blynk application. The utilization of Blynk software enables the remote supervision and manipulation of the system, rendering it a fitting resolution for the surveillance of indoor air quality in residential, commercial, and other indoor settings. In general, this project showcases the capacity of affordable and readily available air quality monitoring systems to aid mine workers and industries in making informed judgments regarding their ambient surroundings. Subsequent research endeavors may concentrate on broadening the scope of identified contaminants by integrating supplementary sensors or amalgamating machine learning algorithms to enhance precision and instantaneous analysis. However, this project establishes a robust basis for developing efficient air quality monitoring systems utilizing easily accessible components and software.

ACKNOWLEDGMENT

We would like to extend our gratitude to our Principal Dr. Shiva Reddy, Director Prof, C. V Tomy, Head of Department Dr. D. Mohan and Coordinator Dr. M. Shailaja for their immense support and guidance. We would also wish to acknowledge our families and dear friends who were a great support while working on this paper.

REFERENCES

[1] Ms Menaga et al. (2019) AIR QUALITY MONITORING SYSTEM USING VEHICLES BASED ON THE IOT. In: www.irjet.net. https://www.irjet.net/volume-6- issue03. Accessed 13 February 2023.

[2] Mr Xue Dong (2021) Design of a filtering car air purifier. In:www.iopscience.iop.org. https://iopscience.iop.org/article/10.1088/1755- 1315/632/5/052095. Accessed 14 February 2023.

[3] Automobile Exhaust Purification System Research Based on ARM. In: Automobile Exhaust Purification System Research Based on ARM | IEEE Conference Publication| IEEE Xplore. https://ieeexplore.ieee.org/document/7545296.

[4] Kennedy Okokpujie et al. (2018) A SMART AIR POLLUTION MONITORING SYSTEM. In: www.researchgate.net.https://www.researchgate.net/publication/328015436(A_Smart_Air_Pollution_Monitoring_System). Accessed 14 February 2023.

[5] Gowda MP et al. (2021) Air Quality Monitoring System – IJERT. In: Air Quality Monitoring System– IJERT. https://www.ijert.org/air-quality-monitoring-system.

[6] Deraman FB et al. (2020) Innovation of air quality detector in passenger car using IoT | Deraman | International Journal of Technology, Innovation and Humanities. In: Innovation of air quality detector in passenger car using IoT | Deraman | International Journal of Technology, Innovation and Humanities. http://journal.iicet.org/index.php/ijtih/article/view/8.

[7] Robu.in, https://robu.in/mq-series-gas-sensor/. Last accessed 29 Mar 2023

[8] ElectronicWings.com, https://www.electronicwings.com/sensors-modules/dht11. Last accessed 29 Mar 2023

[9] Robocraze.com, https://robocraze.com/blogs/post/what-is-pulse-sensor. Last accessed 30 Mar 2023

[10] cowaymega.com, https://cowaymega.com/blogs/blog/what-is-a-hepa-filter. Last accessed 30 Mar 2023

[11] indiancrusaders.com, https://www.indiancrusaders.com/blog/importance-ofactivated-carbon-filter-in-an-air-purifier/. Last accessed 31 Mar 2023

[12] electronicshub.org, https://www.electronicshub.org/getting-started-with-esp32/. Last accessed 31 Mar 2023

[13] techexplorations.com, https://techexplorations.com/guides/blynk/1-what-isblynk/. Last accessed 01 Apr 2023

[14] elprocus.com, https://www.elprocus.com/lcd-16x2-pin-configuration-and-itsworking/. Last accessed 01 Apr 2023