ISSN 2277-2685
IJESR/Apr-Jun. 2024/ Vol-14/Issue-2/928-938
S. Mayuri *et. al.,* / International Journal of Engineering & Science Research

INDOOR AIR QUALITY MONITORING AND OPTIMIZATION SYSTEM

S. Mayuri[1], M. Sathwika[2], J. Raghavi[3], D. Sowmya[4]
[1]Department of EEE, Bhoj Reddy Engineering College for Women, Hyderabad, India
[2,3,4,]UG scholar students Department of EEE, Bhoj Reddy Engineering College for Women, Hyderabad, India

ABSTRACT: In today's fast-paced urban lifestyle, people spend a significant portion of their time indoors, making indoor air quality a crucial determinant of health and well-being. Poor indoor air quality can lead to various health issues, including allergies, respiratory problems, and even long-term health risks.

The existing methods for monitoring indoor air quality often rely on standalone sensors that provide limited data and lack intelligent insights. These systems offer basic readings of air parameters but do not consider the dynamic nature of indoor environments. As a result, users often receive data without context and struggle to make informed decisions regarding air quality improvement. Our proposed system goes beyond traditional air quality monitoring by integrating by integrating it with a power supply. It involves the deployment of sensors for continuous monitoring of indoor air quality, including parameters such as CO_2 levels, humidity, temperature, and air pollutants.This project deals with the indoor air quality monitoring and optimization system. In stage-I the air quality is monitored and displayed on LCD and in stage-II the air quality in the room is controlled.

In stage-I Air Pollution Monitoring is done in which we will monitor the Air Quality parameters on LCD display. The project makes a use of Arduino microcontroller and to measure the air quality using sensors such as dht11(temperature and humidity) sensor, pm2.5 dust particle sensor, MQ2 sensor.

In stage-II Air Pollution Controlling is done in which air quality is controlled as Arduino continuously reads the data from sensors and will be displayed on LCD module. Based on the sensor data Arduino will control the specific device through driver circuits to maintain the air quality.

INTRODUCTION

Monitoring and testing indoor air quality (IAQ) is a crucial procedure to ascertain the amount of pollutants in indoor air that may impact occupants' health and productivity. Comfort, productivity, and overall well-being of employees may all be enhanced by a workplace with good and healthy air quality. Through the monitoring of contaminants and real-time optimization to eliminate them, Cohesion's Indoor Air Quality Program enables building owners and operators to provide occupants with a healthy environment.

In this project, we will create an air pollution monitoring and optimization system that will allow us to monitor the parameters of air quality on an LCD display and regulate the relevant equipment based on sensor data. The project uses an Arduino microcontroller to detect the humidity, temperature, and PM2.5 dust particle levels in the air using sensors like CO2 and dht11 (temperature and humidity) sensors.

The Arduino UNO microcontroller serves as the project's primary controlling device. The Arduino is interfaced with the DHT11 sensor, PM2.5 sensor, CO2 sensor, mist maker, fan, exhaust fan, heater, air ionizer, air inlet, and LCD display. Arduino continually gathers sensor data, which it then displays on an LCD module. Arduino will use driver circuits to regulate the particular device based on the sensor data in order to manage the air quality, particularly with regard to the health and comfort of building inhabitants. This job is accomplished via an embedded C program put onto a microcontroller.

LITERATURE SURVEY

In addition to endangering human health, indoor air quality also has an adverse influence on food crops, wildlife, and the built or natural environment [1-2]. If people are exposed to these poisons or chemicals for an extended length of time without protection, they may also lead to different forms of cancer and respiratory diseases (such as asthma). For instance, due of the makeup of carboxy-hemoglobin, carbon monoxide (CO) may induce severe asphyxiation, headaches, and, if left unprotected for an extended period of time, even death. The World Health Organization (WHO) estimated that air pollution caused 7 million deaths globally in 2014. The International Energy Agency (IEA) also estimated the same amount about [3].

These substances or contaminants are also to blame for a number of environmental disasters, including acid rain and ozone layer depletion. Air pollution is increasing as a result of many human activities, and reducing it is crucial to mitigating the effects of specific initiatives meant to reduce it [4].

The sensors used to measure air quality used to be quite large, heavy, and costly. Currently, the majority of air pollution sensors are designed to detect the five most prevalent air pollutants: particulate matter, nitrous oxide, CO, ozone, and sulfur dioxide. Given its significant impact on human health, air pollution and quality monitoring are very important in today's society. The created air-quality measuring sensor is able to detect and track the prevalence of air pollution in the surrounding regions. It may be used outside as well as inside. Future technical advancements will enable these sensors to become more widely available, less priced, wearable portable air quality monitors that individuals may use to monitor the local air quality [5-7].

Because indoor air quality (IAQ) and indoor air pollution (IAP) have a substantial impact on the overall health and well-being of people who spend most of their time indoors, whether at home or at work, they are issues of concern in many nations. Low IAQ and recurrent exposure to hazardous pollution concentrations may raise global absenteeism and productivity losses as well as substantially increase the cost of healthcare. The issue of IAQ is examined in this book, IAQ Assessment for Smart Environments, which also identifies possible obstacles, possibilities, and gaps in the area [8].

You may find answers to almost every issue in the field with this manual. Prominent domestic and global specialists assist you in establishing and preserving secure and salubrious surroundings in buildings ranging from medical facilities to residential homes. They address an array of inquiries spanning from physiological thresholds and health and comfort impacts to ventilation assessment and staff training initiatives. IAQ is a source to have for information on codes, guidelines, instruments, pollutants, and solutions needed to evaluate, develop, and manage productive and healthy indoor settings [9].

The objective of this study is to enhance the indoor air quality monitoring system created in a previous work, which can measure the amount of a variety of indoor pollutants and temperature conditions in real-time using eight detectors [10].

TECHNICAL ARCHITECTURE

BLOCK DIAGRAM

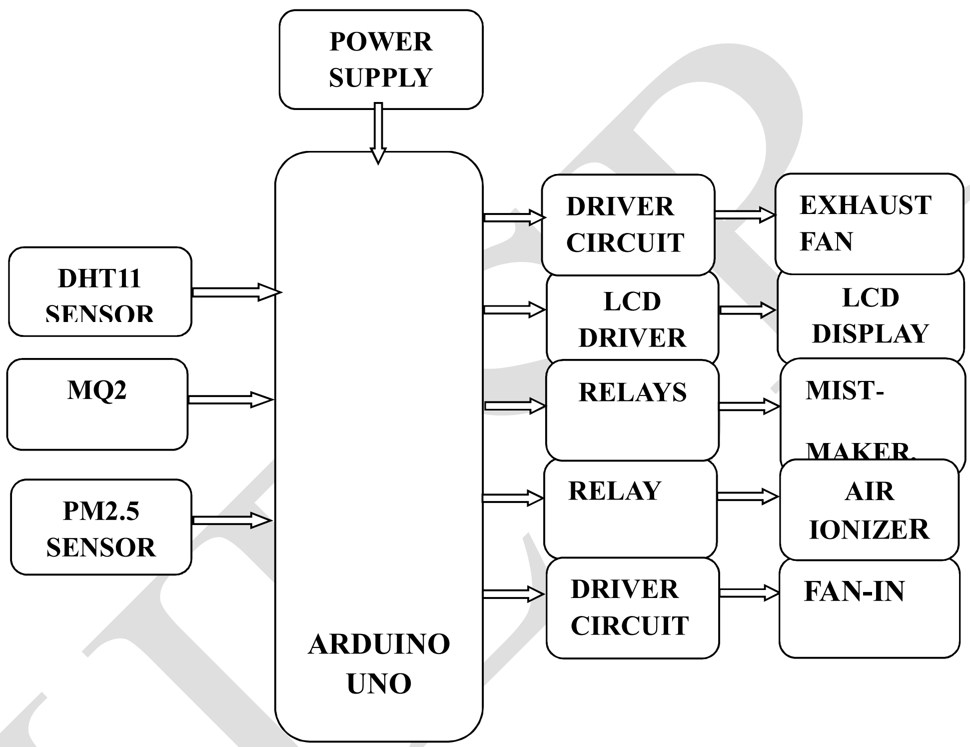

Fig. Block diagram

The main components of the project are DHT11 sensor, MQ2 sensor and PM2.5 sensor for Monitoring. DHT11 sensor is a humidity and temperature sensor that senses the moisture and temperature of the room under monitor. MQ2 sensor is used to sense the gas content in the atmosphere and PM2.5 sensor senses the dust particles up to the range of 2.5 microns. All these contents are represented on the LCD display. The components used for Optimization are Exhaust fan or Fan-Out, Mist maker, Air Ionizer, Heater and Fan-In. Fan-Out optimizes both the smoke and humidity, when the smoke in the room is greater than 150ppm and the humidity is greater than 75%. Mist maker operates when the humidity goes beneath 35%. The air ionizer ionizes the room if the size of the dust particles is beyond 45ug/m^3. If the temperature is less than 30^{o}c the heater turns on. If the temperature is greater than 39^{o}C then Fan-In operates.

CIRCUIT DIAGRAM

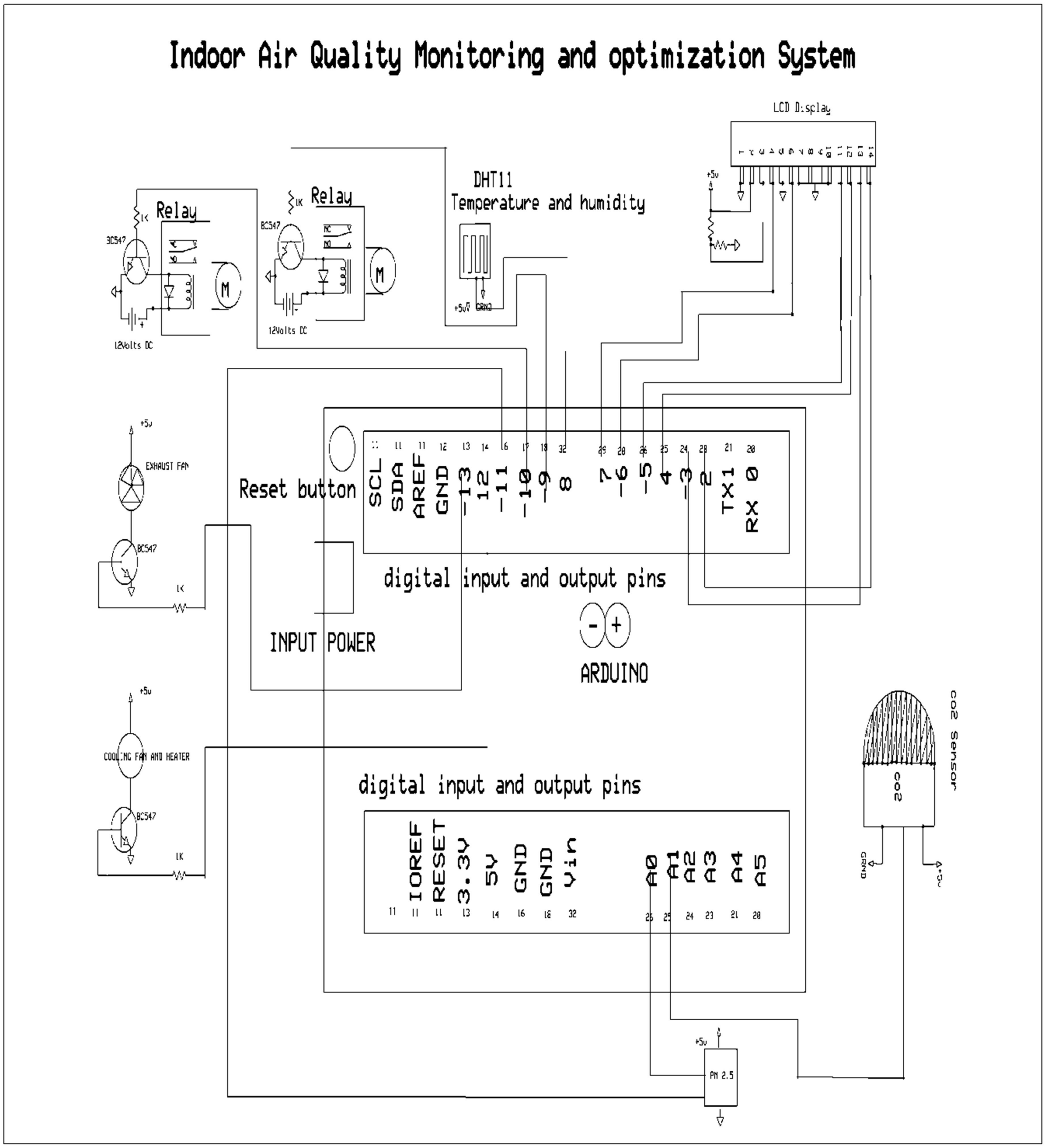

Fig. Schematic diagram of Indoor Air Quality Monitoring and optimization System

The schematic diagram gives the overall view of how the sensors and LCD driver is connected to the Arduino UNO. The MQ2 sensor and PM2.5 sensor are connected to the analog pins of the microcontroller and the DHT11 sensor is connected to the digital pins of Arduino UNO. The reset button is used to reset the LCD driver in case of any malfunctioning of LCD display. Relays are connected to the digital output pins. Transformers are connected to digital pins. Transformers and relays are then connected to the respective optimizing devices.

HARDWARE MODULES

INDOOR AIR QUALITY MONITORING SYSTEM

The complete hardware module is shown below

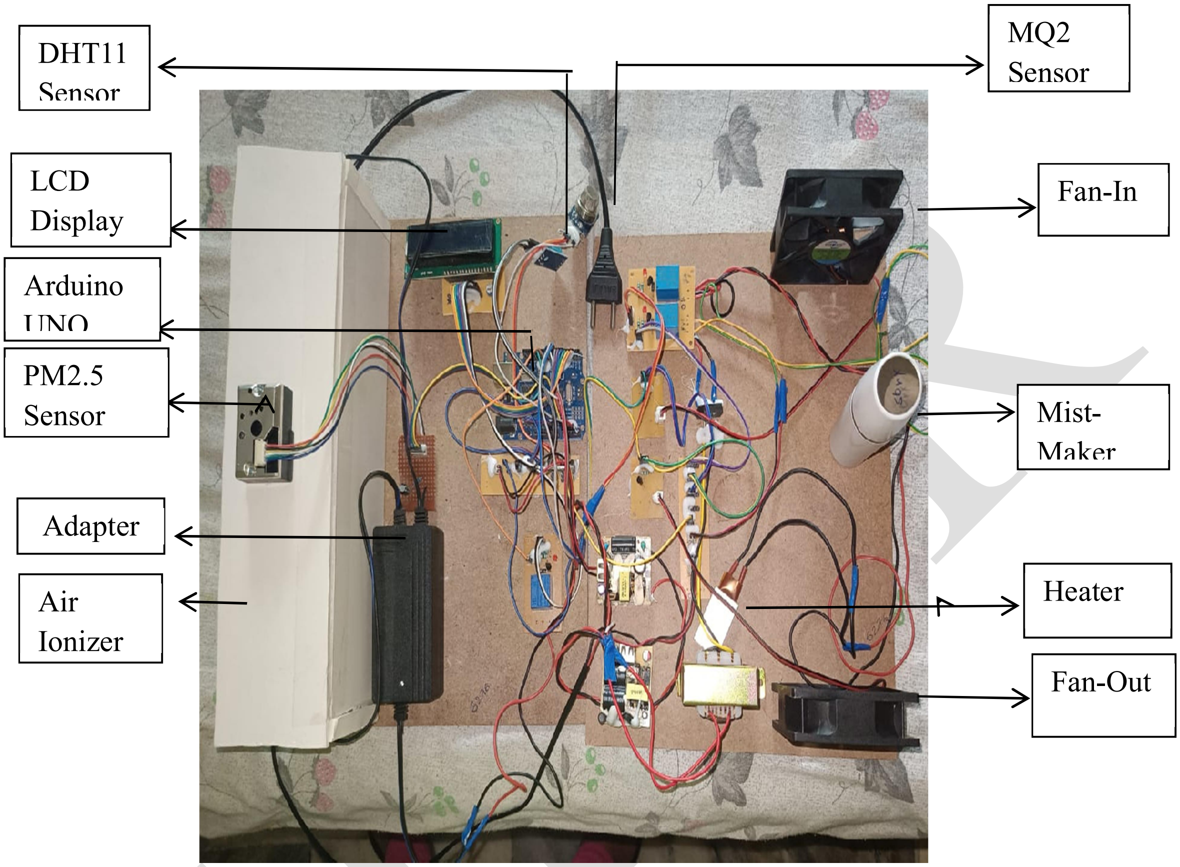

Fig. Indoor Air Quality Monitoring and Optimization System

The Indoor air quality System comprises an Arduino UNO, to which all the sensors are interconnected. The MQ2 sensor detects the concentration of gas in the indoor air, measured in parts per million (PPM). The PM2.5 sensor is a device that detects dust particles with a size of up to 2.5 microns and displays the measurement in micrograms per cubic meter (ug/m3) on an LCD display. The DHT11 sensor detects the temperature and humidity levels in the surrounding environment. The temperature is measured in degrees Celsius, while the humidity is measured as a percentage. In the Arduino UNO, the code is uploaded in advance, and the programming language utilized is Embedded C. The temperature, humidity, dust particle size, and gas/smoke levels within the space are adjusted by the respective equipment to minimize variations.

ISSN 2277-2685
IJESR/Apr-Jun. 2024/ Vol-14/Issue-2/928-938
S. Mayuri *et. al.*, / International Journal of Engineering & Science Research

TESTING AND RESULTS

Case 1

Testing of humidity and temperature sensor

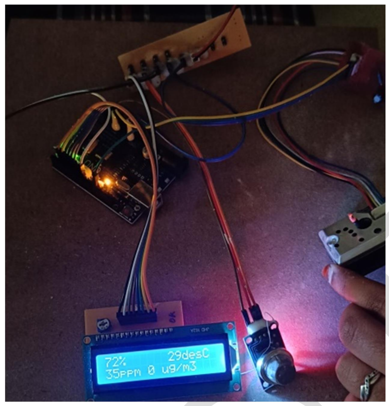

Fig. Testing of humidity and temperature sensor

The LCD display displays welcome to the project immediately after switching on the supply, then after few seconds the lcd display displays the humidity, temperature, CO_2 gas and dust particles. The DHT11 sensor displays both the humidity and temperature in percentage and degree centigrade.

Case 2

Testing of MQ2 sensor

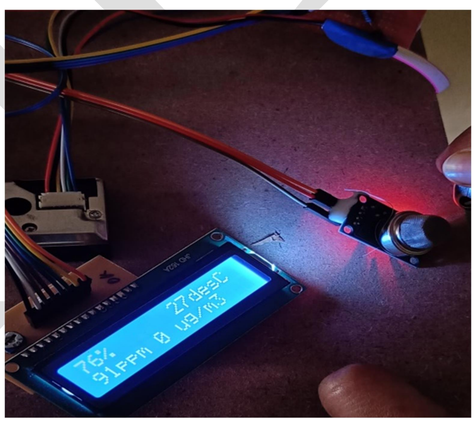

Fig. Testing of MQ2 sensor

Immediately after the power supply is given the LCD display displays the gas content in the atmosphere in parts per million. This is done by MQ2 Sensor. This sensor detects smoke, liquefied natural gas (LNG), butane, propane, methane, alcohol, and hydrogen in the air. If in case there is a change in the content of the gases in the indoor air quality the value of the gas content immediately changes when detected a change. Here the value is changed when the lighter leakage gas is sensed by the MQ2 sensor.

Case 3

Testing of PM2.5 dust particle Sensor

Fig. Testing of PM2.5 sensor

The LCD module displays 0 microns/m^3 in normal conditions. But in case of any dust particles are sensed by the dust particle sensor then the value in the LCD display changes indicating that the dust particles are sensed. The PM2.5 dust particle sensor senses the dust particles up to 2.5 microns.

Case 4

When the humidity is greater than 75%

Fig. Humidity greater than 75%

Research from the Building Science Corporation found that humidity of 70% or higher adjacent to a surface can cause serious damage to the property. Hence, when the humidity inside the room exceeds the level more than 75% which will be displayed on the LCD display then fan out will be turned on immediately to optimize the humidity and the fan out will be operated until the humidity goes beneath 75%.

Case 5

When the humidity is less than 35%

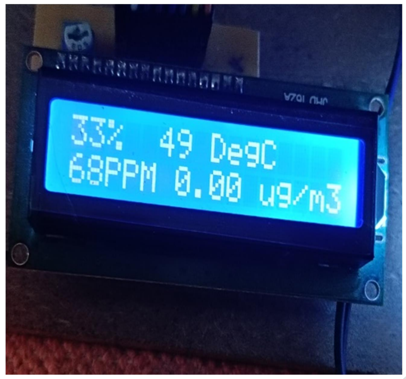

Fig. Humidity lower than 35%

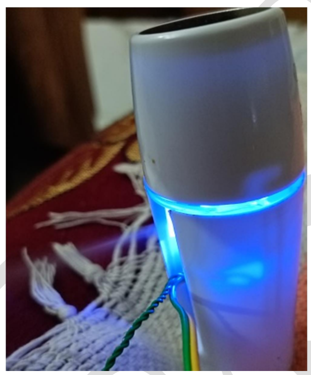

Fig. Mist-Maker is turned on

The Health and Safety Executive recommends that relative humidity indoors should be maintained at 40-70%, while other experts recommend that the range should be 30-60%. Hence, when the humidity inside the room reduced to the level less than 35% then mist maker will be turned on to optimize the humidity and the mist maker will be operated until the humidity becomes greater than 35%.

Case 6

When gas/smoke exceeds 150 ppm.

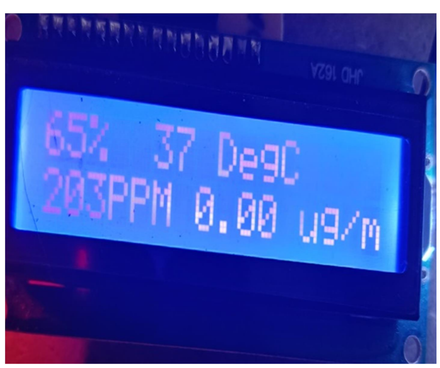

Fig. Gas content greater than 150ppm

When gas/smoke inside the room exceeds 150 ppm which is dispayed on the LCD display then immediately fan out/ Exhaust fan will be turned on. The exhaust fan operates until the gas or smoke content inside the room will be reduced.

Case 7

When dust particles size is greater than 45 ug/m^3

Fig. Dust particles size greater than 45ug/m^3

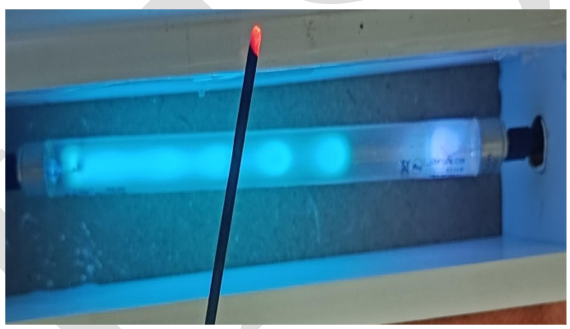

Fig. Air Ionizer is turned on

When the dust particles size inside the room is greater than 45ug/m^3 then the air ionizer operates clearing the dust particles present in the room. Here an incense stick is used to increase the dustparticles inside the room which is sensed by the PM2.5 sensor and inturn displayed on the LCD display. Immediately then after the Air Ionizer turns on optimizing the dustparticles inside the room.

Case 8

When temperature greater than 39^{o}C

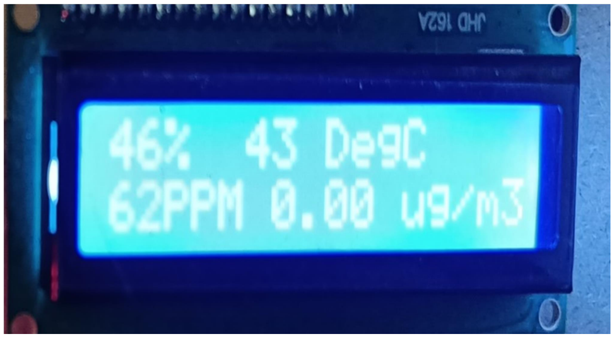

Fig. Temperature greater than 39° C

If the temperature is between 39-40^{0}C, the brain tells the muscles to slow down and fatigue sets in. Hence, when the temperature is greater than 39°C then the Fan-In will operate reducing the excess temperature inside the room.

CONCLUSION AND FUTURE SCOPE

The hardware for the Indoor Air Quality Monitoring and Optimization System has been successfully constructed and tested in a classroom setting. The suggested system is a hardwired system that is directly linked to the power supply. As a result, the system's reaction time is significantly improved and accelerated. This project involves monitoring and displaying the humidity, temperature, gas, and dust particles in the interior environment on an LCD screen. This ensures the indoor air quality of the specific space. If there are any changes in the levels of humidity, temperature, gas, and dust particle size, the relevant devices will function to improve the air quality in the space.

FUTURE SCOPE

We can extend the project by adding GPS module, then the collected data and analysis results will be available to the user through Wi-Fi along with the current location using GPS module.

The project can be extended by adding more sensors like CO, monitoring sensors, moisture of the weather monitoring system. We can even add GSM modem through which we can get the SMS alerting messages about the weather reporting data along with location to the weather reporters or weather station authorities.

The following advancements can also be done in the future:

1. Smart and buildings and integration.
2. Artificial intelligence and machine learning.
3. Sensor technology advancements.
4. Personalized IAQ monitoring.
5. Integration with building Automation systems.
6. Blockchain for data security.
7. Predictive maintenance.
8. Renewable energy integration.

REFERENCES

[1] Kim, Sunyoung, and Eric Paulos, "In Air: measuring and visualizing indoor air Quality.", *Proceedings of the 11th international conference on Ubiquitous computing*, 2009.

[2] Ali Al-Dahoud, Mohamed Fezari, Ismail Jannoud and Thamer AL-Rawashdeh, "Monitoring Metropolitan City Air-quality Using Wireless Sensor Nodes based on ARDUINO and XBEE", *Institute of Advanced Studies in Education Conferences*, 2010.

[3] Kim, Sunyoung, and Eric Paulos. "In Air: sharing indoor air quality measurements and visualizations." *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems,* 2010.

[4] Piedrahita.R, "The next generation of low-cost personal air quality sensors for quantitative exposure monitoring", *Atmospheric Measurement Techniques*, vol. 7, no. 10, pp. 3325-3336, 2014.

[5] V. Siva Krishna, S. Arun, Dr. J.L Mazher Iqbal "Embedded System Based Air Pollution Detection in Vehicles", *International Journal of Emerging Technologies in Computational and Applied Sciences*, vol.12, no.3, pp. 286-289, 2015.

[6] P. Rajendra Chaitanya, N. Sravani and B. Ganesh, "Automated Control System for Air Pollution Detection and Prevention in Vehicles", *International Journal of Advances in Engineering and Technology Research*, vol.4, no.22, pp. 4291-4294, 2015.

[7] Rajkumar, M. Newlin, M. S. Sruthi, and V. Venkatesa Kumar, "IOT Based Smart System for Controlling Co2 Emission", *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, vol.2, no.2, 2017.

[8] Saini, J. Dutta, M. Marques, G. Halgamuge, "Indoor air quality assessments for smart environments", Ambient Intelligence and Smart Environment, 2022.

[9] John. D. Spengler, Jonathan M. Samet, John. F. McCarthy, "Indoor Air quality Handbook", *McGraw-Hill Education*, 2001.

[10] The Optimization of a real time indoor air quality monitoring system, https://ieeexplore.ieee.org/document/999138.