

IOT BASED DETECTION OF TOXIC METALS IN ATMOSPHERE

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Technology degree in Biomedical Engineering

by

SUGANTH.S(40240040)

ROSHAN.B(40240027)



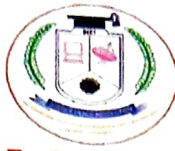
DEPARTMENT OF BIOMEDICAL ENGINEERING
SCHOOL OF BIO AND CHEMICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A++" by NAAC
JEPPIAARNAGAR, RAJIVGANDHISALAI, CHENNAI - 600119

APRIL - 2024



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited "A++" Grade by NAAC | 12B Status by UGC | Approved by AICTE

www.sathyabama.ac.in

DEPARTMENT OF BIOMEDICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Roshan.B (40240027)** and **Suganth.S (40240040)** who have done the project work as a team carried out the project entitled "IOT BASED DETECTION OF TOXIC METALS IN ATMOSPHERE" under our supervision from July 2023 to April 2024.

Internal Guide

Dr.T.Sudhakar

Head of the Department

Dr.T.Sudhakar

Head of the Department
Department of Biomedical Engineering
Sathyabama Institute of Science & Technology
(Deemed to be University)
Category I University by UGC
Jeppiaar Nagar, Rajiv Gandhi Salai,
Chennai - 600 119

Submitted for Viva-Voice Examination held on 5 APRIL 2024

Internal Examiner

External Examiner

DECLARATION

We **ROSHAN.B(40240027)** and **SUGANTH.S(40240040)** hereby declare that the Project Report entitled "**IOT BASED DETECTION OF TOXIC METALS IN ATMOSHPERE**" done by us under the guidance of **Dr. T. SUDHAKAR** is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Biomedical Engineering

DATE: 05.04.2024

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATES



1. Roshan. B (40240027)



2. Suganth. S (40240040)

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to the Board of Management of Sathyabama Institute of Science and Technology for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

We would like to express our sincere and deep sense of gratitude to our Project Guide **Dr. T. SUDHAKAR** for his valuable guidance, suggestions and constant encouragement paved the way for the successful completion of our project work.

We wish to express our thanks to all Teaching and Non-teaching staff members of the Department of Biomedical Engineering who were helpful in many ways for the completion of the project.

I would like to express our thanks to our parents for there unwavering support to us during these years.

ABSTRACT

In this project we are going to make an IOT Based detection of toxic metal contents in the atmosphere. In which we will monitor the Air Quality over a web server using internet and will trigger an alarm when there are presence toxic metals which are said to be the harmful gases are present in atmosphere. By leveraging the power of IoT and data analytics, it contributes to safeguarding the environment and protecting human health in urban and industrialized areas. It will show the air quality in PPM on the LCD and as well as on webpage so that we can monitor it.

Keywords: IOT, Toxic metal Detection, Air Quality, Web Server, PPM.

TABLE OF CONTENTS

CHAPTER	SI. NO.	CONTENT	PAGE NO.
		ABSTRACT	I
		LIST OF FIGURES	III
		LIST OF TABLES	IV
		LIST OF ABBREVIATION	V
CHAPTER 1	1	INTRODUCTION	1
CHAPTER 2	2	LITERATURE SURVEY	2
CHAPTER 3	3	AIM AND SCOPE OF PRESENT INVESTIGATION	7
CHAPTER 4	4	MATERIALS AND METHODS	8
	4.1	MATERIALS	8
	4.2	SENSOR DEVELOPMENT	13
CHAPTER 5	5	RESULT AND DISCUSSION	14
	5.1	RESULT	14
	5.2	DATA INTERPRETATION	15
	5.3	REAL-TIME APPLICATION	18
	5.4	DISCUSSION	20
CHAPTER 6	6	SUMMARY AND CONCLUSION	21
	6.1	SUMMARY	21
	6.2	CONCLUSION	22

LIST OF FIGURES

FIG NO.	NAME OF FIGURES	PAGE NO.
4.1.1	ARDUINO UNO	9
4.1.2	LCD DISPLAY	10
4.1.3	BUZZER	10
4.1.4	METAL OXIDE SENSOR	11
4.1.5	METHODS OF DETECTING TOXIC METALS	12
4.2	METAL OXIDE SENSOR	13
5.1	ARDUINO WITH METAL OXIDE SENSOR	14
5.2	DATA INPUT BLOCK DIAGRAM	17
5.3	PERFORMANCE ANALYSIS OF METAL CONTENT	19

LIST OF TABLES

TAB. NO.	DESCRIPTION	PAGE NO.
5.1	DATA ANALYSIS OF MERCURY METAL IN ATMOSPHERE	14

LIST OF ABBREVIATION

ABBREVIATION	EXPANSION
AQI	AIR QUALITY INDEX
DHT	DIGITAL TEMPORATURE AND HUMIDITY
ESP	ELECTRONIC STABILITY PROGRAM
GPS	GLOBAL POSITION IN SYSTEM
IoT	INTERNET OF THINGS
IDE	INTEGRATED DEVELOPMENT ENVIRONMET
LCD	LIQUID CRYSTAL DISPLAY
MATLAB	MATRIX LABORATORY
MCU	MICRO CONTROLLER UNIT
MOS	MACRO-BASED OPERATING SYSTEM
PWM	PULSE WIDTH MODULATION
SC	SENSOR CLOUDS
USB	UNIVERSAL SERIAL BUS
Wi-Fi	WIRELESS FIDELITY
WSN	WIRELESS SENSOR NETWORK

CHAPTER 1

INTRODUCTION

The rising concentrations of hazardous metals in the environment have become a serious problem in recent decades, posing significant threats to ecosystems and human health. Important natural resources have been contaminated as a result of industrial processes, mining operations, and agricultural practices that emit heavy metals including lead, mercury, cadmium, and arsenic into the air, water, and soil. Toxic metal exposure can cause serious health problems, such as neurological diseases, improper development, and numerous malignancies. The urgent need to solve this environmental and public health catastrophe has prompted research into cutting-edge technologies for effective, real-time monitoring and detection of harmful metal contaminants.

In this context, the Internet of Things (IoT) has emerged as a paradigm shifter, providing an unmatched chance to improve how we monitor, identify, and react to environmental pollution, particularly toxic metal contamination. The Internet of Things (IoT) is a large network of interconnected sensors, gadgets, and systems that can gather and transmit data on their own. This capacity has made it possible to create scalable and affordable IoT-based systems for environmental monitoring.

IoT-based detection systems present a promising avenue for proactive and data-driven decision-making as governments, companies, and communities work to alleviate the negative consequences of toxic metal contamination. This review study aims to give useful insights for researchers, policymakers, and practitioners working towards a cleaner and safer environment by illuminating the current state of IoT-based toxic metal detection systems. In the end, it highlights the crucial part that IoT plays in the ongoing fight against toxic metal contamination and provides a glimpse into what environmental monitoring and sustainability can look like in the future.

CHAPTER 2

LITERATURE SURVEY

Elisavet Stavropoulou (2020) Air pollution is a significant issue affecting public health, and individual health. It includes PM, ozone, nitrogen oxides, sulfur dioxide, VOCs, dioxins, and heavy metals. These pollutants cause respiratory, cardiovascular, and neurological diseases. Addressing this threat requires public awareness, multidisciplinary approaches, and sustainable solutions.

Harsh Gupta (2019) The paper proposes an IoT-based Air Quality Monitoring System for Smart Cities, enabling real-time data access through smart devices to measure air quality indexes like temperature, humidity, CO₂, and PM_{2.5}. The system analyzes the impact on city dwellers and is accessible globally through Android applications.

Aulichori (2021) This research aims to develop an IoT-based mine air quality monitoring system using sensors like gas, temperature, and humidity, enhancing environmental security by detecting potential threats and sending alerts to diggers and security officials.

Sarita Jiyal (2020) Air pollution is a major issue in developing countries like India, affecting the economy and causing premature death. Urbanization leads to resource loss, and smart sustainable cities can balance resources. Internet of Things monitoring is crucial for environmental protection.

Deeksha Singh Katiyar (2022) Urbanization, industrialization, and deforestation cause air pollution, causing health issues like asthma and respiratory infections. Air Health, an IoT-enabled smart device, monitors pollution levels, calculates air quality index, and provides remote monitoring for public health.

Swati Dhingra (2019) IoT devices can sense and interact with their surroundings, addressing global air pollution concerns. A three-phase air pollution monitoring system using gas sensors, Arduino IDE, and Wi-Fi module is proposed, allowing users to access data and predict future AQI levels.

Lakshmi Narayanan (2022) Air pollution is a pressing issue due to automobile industry growth. This paper proposes a system using an Atmega 328p micro-controller, sensors, GPS, and ESP8266 module to monitor air quality. An Android app helps users find pollution-free driving routes.

Zhibin Liu (2021) Indoor air quality monitoring is crucial for human health, and an IoT-based IAQD in residential buildings has been tested. Results show increased PM2.5 concentrations during cooking and increased CO2 concentrations with closed doors, posing health risks.

Bhommi (2022) This paper proposes a framework for monitoring air quality and controlling it using IoT devices. It uses redox response mechanisms to convert toxic gases from catalytic converters and fumes to less harmful toxins. The system uses filters, lasers, and MATLAB programming for graphical examination.

Bikash Kumar Moharana (2020) Air quality is deteriorating rapidly, causing deaths of seven million people annually. A prototype air quality monitoring system combines a Node MCU ESP32, MQ-135 gas sensor, and DHT-11 temperature and humidity sensor module. This system offers small size, efficient power usage, and cost advantages, enabling better decision-making and potential for smart cities to control pollution levels.

Harsh Gupta (2019) The paper proposes an IoT-based Air Quality Monitoring System for Smart Cities, enabling real-time data access through smart devices to measure air quality indexes like temperature, humidity, CO2, and PM2.5. The system analyzes the impact on city dwellers and is accessible globally through Android applications.

Arun Kumar (2019) Cities are under pressure to continue being livable as the global population moves towards metropolitan areas. The deteriorating state of the world's cities' air in recent years has been a major source of concern. In order to make a city smart and livable, it is vital to regularly check the air quality index.

Abdulla Gani (2019) In technologies like the Internet of Things (IoT), wireless sensor networks (WSN), and sensor clouds (SC), data collection is a crucial component of sensor devices. In recent years, a variety of literature in these research fields has been published to suggest various models, architectures, and contributions to the domains. An important literature volume has been published to aid data collection because efficient data collection is crucial for lowering energy consumption, latency, network lifetime, and overall cost.

Saita Jiyal (2020) The idea of a smart, sustainable city can be applied to resource management. Excessive resource loss will undoubtedly generate issues for the next generation, While excessive resource use results in air pollution. Then, in order to monitor air pollution, it is important to predict it in advance.

Bommi (2020) This paper proposes a framework for monitoring air quality and controlling it using IoT devices. It uses redox response mechanisms to convert toxic gases from catalytic converters and fumes to less harmful toxins. The system uses filters, lasers, and MATLAB programming for graphical examination.

Martin m (2020) Cardiovascular and respiratory conditions can cause issues. In order to conduct a more in-depth investigation of gas concentration, the concept was applied in the evaluation system employing electrochemical sensors (MQ4, MQ9, and MQ135) to send the data to the cloud through the internet of things (IoT) platform. air quality evaluation and air pollution.

Ashokkumar Janarthanan (2022) Data collection is an essential part of sensor devices in technologies like the Internet of Things (IoT), wireless sensor networks (WSN), and sensor clouds (SC). Numerous works in these research fields have been published recently to offer different models, architectures, and contributions to the domains.

Elisavet Stravropoulou (2020) Air pollution is a significant issue affecting public health, and individual health. It includes PM, ozone, nitrogen oxides, sulfur dioxide, VOCs, dioxins, and heavy metals. These pollutants cause respiratory, cardiovascular, and neurological diseases. Addressing this threat requires public awareness, multidisciplinary approaches, and sustainable solutions.

Swati Dhingra (2020) IoT devices can sense and interact with their surroundings, addressing global air pollution concerns. A three-phase air pollution monitoring system using gas sensors, Arduino IDE, and Wi-Fi module is proposed, allowing users to access data and predict future AQI levels.

Deeksha Singh (2022) Study introduces the Air Health smart device, an Internet of Things (IoT) enabled smart device that gives geographically based pollution insights by detecting and measuring the levels of various air pollutants, computing the air quality index at the installed location, along with temperature and humidity levels.

Muladi muladi (2019) Maintain a healthy body and excellent performance, the composition of the gas content in the learning environment needs to be continuously monitored. With the help of wireless LAN (WLAN) networks and Internet of Things technology, this study created a system for monitoring the air quality in classrooms. The concentration of O₂, CO, CO₂, and NH₃ gases at various measuring points throughout the classroom is used to calculate the air quality.

Zhibin liu (2021) The Internet of Things (IoT) has been used to design and test an indoor air quality detector (IAQD) that can measure CO₂, PM_{2.5}, temperature, and humidity in residential buildings.

Niranjana (2022) Given the current exponential growth of many industries, particularly the automotive industry, air pollution is one of the serious problems that needs to be addressed quickly. Because of the and quality of the air needs to be properly monitored and managed in order to avoid these issues to safeguard the entire eco system. The monitoring of air quality using an Atmega 328p microcontroller, various air quality sensors, including a carbon monoxide sensor, a methane sensor, and a gas sensor, as well as a GPS system and an ESP 8266 module that aids in updating the sensed data to a centralized monitoring hub cum data-base, has been proposed in this paper.

Bikash Kumar Moharana (2020) Air quality is deteriorating rapidly, causing deaths of seven million people annually. A prototype air quality monitoring system combines a Node MCU ESP32, MQ-135 gas sensor, and DHT-11 temperature and humidity sensor module. This system offers small size, efficient power usage, and cost advantages, enabling better decision-making and potential for smart cities to control pollution levels.

Lakshmi Narayanan (2011) Air pollution is a pressing issue due to automobile industry growth. This paper proposes a system using an Atmega 328p micro-controller, sensors, GPS, and ESP8266 module to monitor air quality. An Android app helps users find pollution-free driving routes.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

- ❖ The aim and scope of IoT-based detection of toxic metals in the atmosphere are crucial in addressing environmental pollution and its impact on public health. This innovative application of IoT technology has a specific focus on monitoring toxic metal concentrations in the air.
- ❖ Safeguard the Environment and to assess the impact of atmospheric pollution on ecosystems, air quality, by helping to reduce environmental damage.
- ❖ This field encompasses a wide range of applications, from industrial settings to urban environments, and plays a significant role in fostering sustainable and responsible environmental practices.
- ❖ The field continuously evolves with emerging technologies, including sensor innovations, data analysis improvements, and communication protocols, aimed at enhancing the accuracy and efficiency of monitoring.

CHAPTER 4

MATERIALS AND METHODS

4.1 MATERIALS

- Arduino Uno
- 16X2 LCD
- 3.Breadboard
- Metal oxide sensor
- 10K potentiometer
- 1Kohmresistors
- 220ohmresistor
- Buzzer

Arduino uno:

The Arduino Uno is a versatile microcontroller board based on the ATmega328P chip. It features a simple yet powerful design that makes it ideal for beginners and experienced makers alike. The board comes with a variety of input and output pins, including digital I/O pins, analog input pins, and PWM (Pulse Width Modulation) pins, allowing users to connect various sensors, actuators, and other electronic components.

Key features of the Arduino Uno include its ease of use, thanks to the Arduino IDE (Integrated Development Environment), which provides a user-friendly interface for writing, compiling, and uploading code to the board. It supports the C/C++ programming language, making it accessible to a wide range of users, from hobbyists to professionals.

The Arduino Uno can be powered via USB connection or an external power supply, making it suitable for both desktop and standalone applications. It has built-in USB communication for serial communication with a computer, enabling data exchange and debugging.

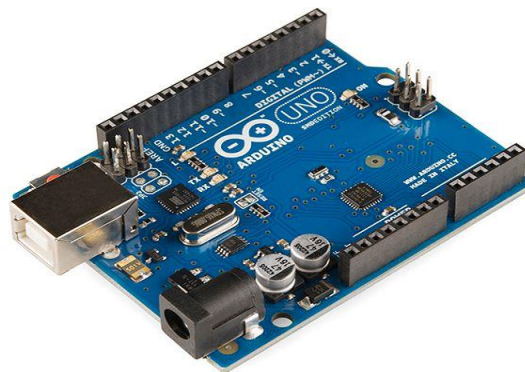


Fig 4.1.1 Arduino Uno

LCD display:

LCD displays are ubiquitous in various electronic devices, ranging from smartphones and tablets to digital watches, calculators, and instrumentation panels. They offer several advantages, including low power consumption, lightweight design, and compatibility with a wide range of applications.

LCDs are used to display data in various formats, including charts, graphs, and gauges. They are essential in scientific instruments, medical devices, and monitoring systems for presenting real-time data and trends.

LCDs are used to visually present information such as text, numbers, graphics, and images. They are commonly found in consumer electronics devices like digital clocks, microwave ovens, and car dashboards.

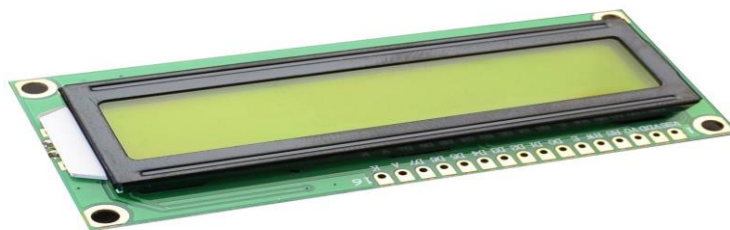


Fig 4.1.2 LCD Display

Alert system:**Buzzer:**

Buzzers are versatile components used in a wide range of electronic devices and systems to provide audible alerts, notifications, and feedback to users. They play a crucial role in enhancing the usability, safety, and functionality of various applications.



Fig 4.1.3 Buzzer

Metal Oxide Sensor:

Metal oxide semiconductors are commonly used as gas sensors in environmental monitoring and in industrial applications, allowing the production of small, low-cost devices.

ZnO is able to detect a great variety of gases, such as CO₂, H₂S, NO₂

Conductometric semiconducting metal oxide gas sensors have been widely used and investigated in the detection of gases.

This MOS mainly used in the industries such a use of high metal content and also in the dentistry fields.



Fig 4.1.4 Metal Oxide Sensor

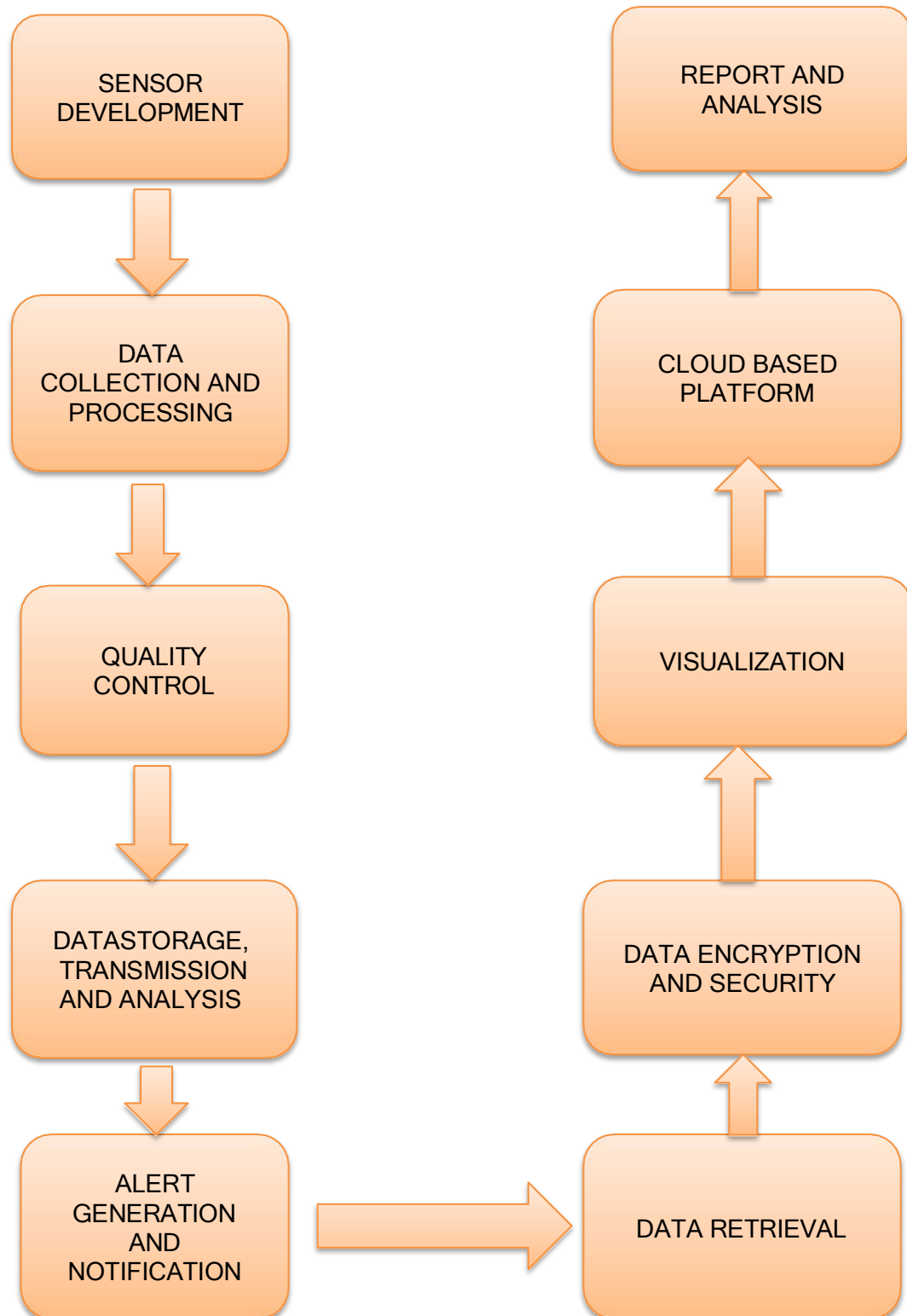


Fig 4.1.5 Methods of Detecting Toxic Metals

4.2 SENSOR DEVELOPMENT

- A metal oxide sensor (MOS) is a type of gas sensor that operates based on the changes in the electrical conductivity of a metal oxide material when it comes into contact with specific gases or vapors.
- These sensors are commonly used for detecting and measuring the concentration of various gases, especially in applications related to air quality monitoring, industrial safety, and environmental control.



Fig 4.2 Metal Oxide Sensor

CHAPTER 5

RESULT AND DISCUSSION

5.1 RESULT

Resulting this project, we have used metal oxide sensor to detect the mercury content in the atmosphere which is harmful to human health. We visited Ambattur Dental service industry and tested in various department of industry such as Raw Materials, Procurement, Production, Quality Control, Research and Development, Maintenance, Packaging and Shipping. Hence, the results shown in tabulation (tab 5.1).



Fig 5.1 Arduino with Metal Oxide Sensor

Sample ID	Location	Mercury Content	Remarks
1	Raw Material Procurement	143	High Range
2	Production	137	Normal Range
3	Quality Control	133	Normal Range
4	Research and Development	120	Normal Range
5	Maintenance	118	Low Range
6	Packaging and Shipping	118	Low Range

Table 5.1 Data Analysis of Mercury Metal in Atmosphere

5.2 DATA INTERPRETATION

Correlation Analysis:

Investigate correlations between toxic metal concentrations and other environmental factors, such as weather conditions, industrial activities, or traffic volume. Identify potential sources or factors influencing toxic metal levels.

Weather conditions:

Investigate the correlation between toxic metal concentrations and weather parameters such as temperature, humidity, wind speed, and precipitation. Determine if certain weather conditions contribute to the dispersion or accumulation of toxic metals in the atmosphere.

Industrial Activities:

Analyze the correlation between toxic metal levels and industrial activities such as manufacturing, mining, or combustion processes. Assess the impact of industrial emissions on atmospheric concentrations of toxic metals.

Traffic Volume and Transport:

Explore the correlation between toxic metal concentrations and traffic-related factors such as vehicle density, road traffic, and transportation routes. Determine if vehicular emissions contribute to elevated levels of toxic metals in urban areas.

Land Use and Urbanization:

Examine the correlation between toxic metal concentrations and land use characteristics such as urbanization, industrial zones, or agricultural areas. Assess the influence of land use patterns on atmospheric pollution levels.

Proximity to Pollution Sources:

Investigate the correlation between toxic metal concentrations and proximity to known pollution sources such as industrial facilities, waste disposal sites, or mining operations. Determine if spatial proximity to pollution sources affects atmospheric contamination levels.

Temporal Patterns:

Analyze the correlation between toxic metal concentrations and temporal factors such as time of day, day of the week, or season. Identify temporal patterns in toxic metal pollution levels and assess their significance.

Biological and Ecological Factors:

Explore the correlation between toxic metal concentrations and biological or ecological indicators such as vegetation health, wildlife populations, or ecosystem diversity. Assess the impact of toxic metal pollution on ecological systems and biodiversity.

Health Outcomes:

Investigate the correlation between toxic metal concentrations and health outcomes such as respiratory diseases, cardiovascular problems, or cancer incidence rates. Determine if elevated levels of toxic metals in the atmosphere are associated with adverse health effects in exposed populations.

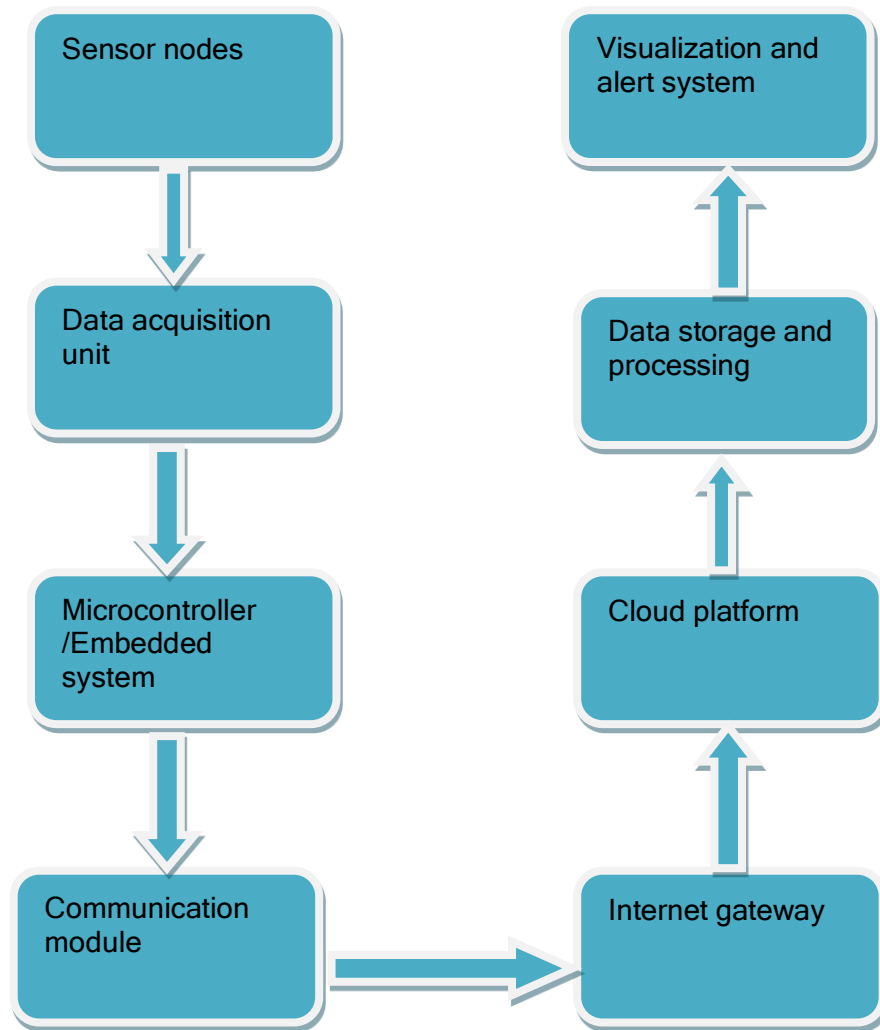


Fig 5.2 Data Input Block Diagram

5.3 REAL-TIME APPLICATION

Early Warning Systems:

IoT sensors continuously monitor air quality for toxic metal concentrations. Real-time data analysis allows for the immediate detection of spikes or hazardous levels, enabling early warnings to be issued to authorities and the public.

Industrial Emissions Monitoring:

Industries that produce toxic metal emissions, such as manufacturing plants or refineries, can deploy IoT sensors to monitor air quality in real time. This allows for proactive measures to be taken to reduce emissions and mitigate environmental impact.

Urban Air Quality Monitoring:

IoT sensors installed in urban areas can provide real-time data on air quality, including levels of toxic metals. This information can be used by city planners, policymakers, and health authorities to assess pollution levels and implement measures to improve air quality.

Environmental Compliance:

Companies operating in industries with strict environmental regulations can use IoT-based detection systems to ensure compliance with air quality standards in real time. Data collected by sensors can be logged and analyzed to demonstrate regulatory compliance.

Public Health Protection:

Real-time monitoring of toxic metal concentrations in the atmosphere helps protect public health by providing timely information on potential hazards. Authorities can issue advisories or implement preventive measures to reduce exposure and minimize health risks.

Emergency Response Management:

In the event of an environmental emergency, such as a chemical spill or industrial accident, real-time data from IoT sensors can aid emergency responders in assessing the situation and implementing appropriate measures to protect public safety and the environment.

Community Engagement:

Real-time air quality data collected by IoT sensors can be made available to the public through online platforms or mobile apps. This promotes transparency and empowers communities to take informed actions to protect their health and the environment.

Scientific Research:

Researchers can use real-time data from IoT-based detection systems to study the dynamics of atmospheric pollution, track pollution trends over time, and investigate the sources and impacts of toxic metal emissions on ecosystems and human health.

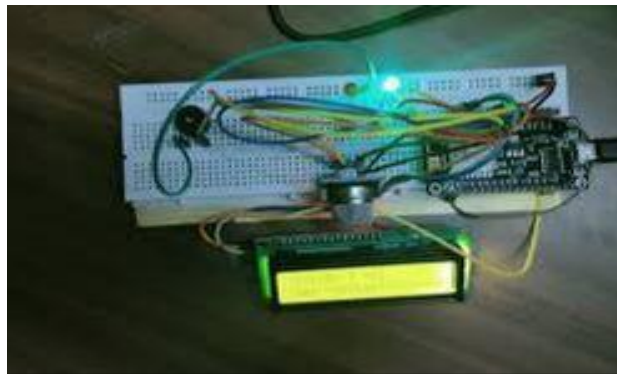
Performance Analysis:

Fig 5.3 Performance Analysis of Metal Content

5.4 DISCUSSION

The industrial visit to a dentistry factory predominantly utilizing mercury-based equipment, provided a first and insight into the manufacturing processes and safety protocols associated with dental equipment production. The visit highlighted the significant mercury in dental applications, particularly dental amalgam for fillings.

Throughout the tour embassies was placed on stringent safety measures to mitigate potential health and environmental risks post by handling, absorbing the intricate assembly lines and quality control procedures underscored the precision and care essential in dental equipment and manufacturing.

We visited the Ambattur dental service industry, we placed our sensor for testing the presence of toxic metal in the particular environment. We detected the mercury metal according to the data provided to the sensor. We got an output of low range by the sensor which indicates the low range of mercury metal present in the atmosphere. Resulting there is no effect on human health.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The project's primary objective is to focus on the development and implementation of a novel system for monitoring and detecting toxic metals mercury and arsenic in the atmosphere using Internet of Things (IoT) technology.

The project aims to address the critical need for real-time monitoring of air quality to safeguard human health and the environment from the adverse effects of toxic metal pollution. These sensors are integrated into an IoT network, allowing for continuous monitoring of air quality across various locations.

The collected data is then analyzed to identify trends, patterns, and potential sources of contamination. Additionally, the project includes the development of an alerting system to notify stakeholders when toxic metal levels exceed safe limits. Overall, the project represents a significant step forward in environmental monitoring technology, providing actionable insights to protect public health and the environment from the harmful effects of air pollution.

6.2 CONCLUSION

In conclusion, our report represents a pivotal advancement in environmental monitoring and public health protection. By leveraging IoT technology and metal oxide sensors, the project has successfully developed a system capable of real-time monitoring and detection of harmful metals in the air.

The implementation of an IoT network has enabled continuous monitoring of air quality, providing stakeholders with timely insights into potential environmental hazards. Enhancing our understanding of the dynamics of air pollution and its impacts on human health and ecosystems.

The development of an alerting system further enhances the project's effectiveness by notifying stakeholders when toxic metal levels exceed safe limits, enabling proactive interventions to mitigate risks and protect public health. Overall, the project underscores the importance of technological innovation in addressing complex environmental challenges and emphasizes the value of collaborative efforts between researchers, policymakers, and communities in safeguarding the environment and promoting sustainable development.

REFERENCES

- 1) Arun kumar, A. A. Hapsari, A. I. Hajamydeen and M. I. Abdullah, "A Review on Indoor Air Quality Monitoring using IoT at Campus Environment", vol. 7, (2019) pp. 55-60.
- 2) Aulia chori, J. J.Carbajal-hernández, L. P.Sánchez-Fernández, J. A. Carrasco-Ochoa and J. F. Martínez-trinidad, "Assessment and prediction of air quality using fuzzy logic and autoregressive models", *Atmos. Environ.*, vol. 60, (2021) pp. 37-50.
- 3) Bikash Kumar Moharana, S. N. Syed Abdul Mutalibetal., "Spatial and temporal air quality pattern recognition using environmetric techniques: A case study in Malaysia", *Environ. Sci. Process. Impacts*, vol. 15, no. 9, (2020) pp. 1717-1728.
- 4) Bommi. R. M, Vasantha Pradeep and Dr. V. Ilaiyaraja, "Analysis and control the air quality using Node MCU", *International Journal of Advance Research Ideas and Innovations in Technology*, April 2018.' (2022) pp. 418-423.
- 5) Deeksha Singh katiyar, K. Swedha and T. Dubey, "Analysis of Web Authentication Methods Using Amazon Web Services", 9th International Conference on Computing Communication and Networking Technologies (ICCCNT), (2022) pp. 1-6.
- 6) Deeksha singh, B. W. Dionova, M. N. Mohammed, S. Al-Zubaidi and E. Yusuf, "Environment indoor air quality assess me M. N. Mohammed, "Investigation on Carbon Monoxide Monitoring and Alert System for Vehicles", 2019 IEEE 15th Int. Colloq. Signal Process. Its Appl., no. March, pp. 239-242, 2019.nt using fuzzy inference system", *ICT Express*, no. 2, (2022) pp. 0-9.
- 7) Elisavet Stavropoulou, S. R. Enigella and H. Shahnasser, "Real Time Air Quality Monitoring", 10th International Conference on Knowledge and Smart Technology (KST), 2018 pp.182-185.
- 8) Elisavet Stavropoulou B.W. Jo and R. M.A. Khan, "An internet of things system for underground mine air quality pollutant prediction based on azure machine learning", *Sensors (Switzerland)*, vol. 18, no. 4, (2020) pp. 270-271.

- 9) Lakshmi Narayanan. K, S. Kumar and A. Jasuja, "Air quality monitoring system based on Iot Using Raspberry Pi", International Conference on Computing Communication and Automation (ICCCA), (2022) pp. 1341-1346.
- 10) Martin. M, A. Aggarwal, T. Choudhary and P. Kumar, "A Fuzzy Interface System for Determining Air Quality Index", pp. 10-14 (2020)
- 11) Saita Jiyal, A. A. Hapsari, A. I. Hajamydeen and M. I. Abdullah, "A Review on Indoor Air Quality Monitoring using IoT at Campus Environment", Int. J. Eng.Technol.7 55-60, vol. 7, (2020) 2018 pp. 55-60.
- 12) Saritajiyal S., Chanthakit and C. Rattanapoka, "MQTT Based Air Quality Monitoring System using Node MCU and Node-RED", Seventh ICT International Student Project Conference (ICT-ISPC), (2020) pp. 182-185.
- 13) Sarwar. B, I. S. Bajwa, S. Ramzan, B. Ramzan and M. Kausar, "Design and application of fuzzy logic-based fire monitoring and warning for smart buildings", Symmetry (Basel)., vol. 10, no. 11, 2018 pp. 1-2.
- 14) Silvaetal. J, "A Hybrid Application for Real-Time Air Quality Monitoring",5th Experiment International Conference (exp.at'19), 2019 pp. 270-271.
- 15) Swati Dhingra., D. Wang, C. Jiang and Y. Dan, "Design of air quality monitoring system based on Internet of Things", 10th International Conference on Software Knowledge Information Management Applications (SKIMA), (2019) pp. 418-423.
- 16) Zhibin liu A. J. Alabdullah, B. I. Farhat and S. Chtourou, "Air Quality Arduino Based Monitoring System", 2nd International Conference on Computer Applications Information Security (ICCAIS), (2021) pp. 1-5.
- 17) Zhibin liu M. N. Mohammed, "Investigation on Carbon Monoxide Monitoring and Alert System for Vehicles", 2019 IEEE 15th Int. Colloq. Signal Process. Its Appl., no. March, (2021) 2019 pp. 239-242.