AIR POLLUTION MONITORING SYSTEM

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In the name of ALLAH, the most benevolent, the most courteous

CERTIFICATE OF CORRECTNESS AND APPROVAL

It is certified that work contained in this thesis **"Air Pollution Monitoring System ",** was carried out by **Malik Saad Raees, Syed Tauqeer Ul Hassan, Saleh Shah, Hammad Qazi** under the supervision of **Assoc. Professor Brig. Fahim** for partial fulfillment of Degree of Bachelor of Electrical (Telecommunication) Engineering, is correct and approved.

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DECLARATION OF ORIGINALITY

We hereby declare that no portion of work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

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ABSTRACT

In the last several years, growing scientific evidence has indicated that the pollutant levels within homes can sometimes be higher than in outdoor air, due to the modern airtight home structure. Most of our time is spend indoors, so poor indoor air quality can put us at risk for health problems from short-term eye and throat allergies-to long-term effect like cancer and even death.

On 22nd January 2014 it was reported that four person of the family including husband, wife and their two children were found dead due to suffocation caused by gas leakage. In another case, three real brothers present in the room went unconscious due to suffocation and were rushed to Civil Hospital where doctors confirmed death of the two brothers while third's condition was also declared serious. A couple and their two children sustained burn injuries in a blast that occurred due to gas leakage. These are only a few incidents while there are a lot more all around the world whereas minor allergies are not reported.

The mostly encountered hazardous gases inside buildings are Carbon-dioxide, Carbon monoxide, Methane and Ammonia. Most of the dangerous gases are colorless and odorless (for example Carbon-monoxide-the silent killer) and the odorous ones (for example Hydrogen Sulfide) are harmful at low concentrations. So, some detecting mechanism is needed to aware us of these dangerous gases at a concentration not dangerous for human health, so that the residents can take timely action to get rid of the gas source.

Gas detectors or sensors available in the market can sense/detect only one gas in one module. Moreover, if user is not present near the detector, it cannot control the safety providing devices. Therefore one compact indoor device for detection of four dangerous gases carbon-dioxide, carbon-monoxide, hydrogen sulfide and methane is designed and implemented. When gas is detected the user is informed via visual indications. Safety device (e.g. exhaust fan) will be turned on automatically after gas detection to evacuate the gas to keep its concentration as low as possible. The user can take action manually (i.e., turning gas evacuating device on or gas sources off via switch) or via app visual. In case of manual action, the user at the mobile end can send a pre-defined text message to know the status of the devices at the residence and can turn any device on or off according to his will. Thus, an Air Pollution Monitoring System is designed and implemented to provide user with all the features mentioned above.

DEDICATION

"If Allah assists you, then there is none that can overcome you, and if He forsakes you, who is there then that can assist you after Him? And on Allah should the believers rely." (3:160)

Dedicated to our beloved families and country Pakistan.

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CHAPTER 1

INTRODUCTION

1.1 Background

In 1914, Alexander Graham Bell observed:

Try quantifying an odour if you're looking for a new scientific discipline. Have you ever tried to quantify an odour? Is it possible to detect whether one odour is just twice as strong as another? Is there any way to quantify the variety of odours? [1] "It is patently clear that humans possess a vast olfactory palette, ranging from the fragrance of violets and roses to that of asafetida. Despite Bell's observation, the field of olfaction did not develop into a distinct scientific discipline until the 1950s and beyond.

The term "electronic sensing" refers to the capability of using sensors and computerised pattern recognition software to mimic human perception. Researchers have been working on an electronic that can detect and categorise odours and tastes since 1982 [2].

1.2 Problem Statement

Since last 200 years, mankind has begun to significantly alter the composition of the atmosphere through pollution. Although air is still made up mostly of oxygen and nitrogen, mankind, through its pollution, has increased the levels of many trace gases, and in some cases, released completely new gases to the atmosphere. Some of these trace gases, presented in elevated concentrations, can be harmful to both humans and the environment.

1.3 Proposed Solution

In order to solve this problem, we suggest building a "Smart ," which consists of an electronic connected to a device management and monitoring system that is GSM-interfaced. The four most dangerous gases—carbon dioxide, carbon monoxide, hydrogen sulphide, and methane—can all be detected and controlled by one single indoor device through GSM.

1.4 Impetus

A rise in the number of unanticipated fatalities from gas poisoning has been linked to both the negligence of residents and the increased frequency with which load shedding has happened. This work is motivated by incidents from all across the world, most recently from Pakistan. In Quetta, Pakistan, an explosion at a home in the Pashtunabad area killed one and injured three [3]. The family claimed that they were preparing for Fajr prayers when the device went off. The explosion completely destroyed all six of the house's rooms. The power of the explosion was so great that it demolished nearby buildings and utility lines.

The second occurrence occurred in Qilla Saifullah, Pakistan [4] when two brothers were getting ready for bed and switched on a space heater. Because the oxygen in the room was depleted by the coal-powered heater, it is likely that the victims died of asphyxiation. Local medical professionals quickly declared them dead upon arrival.

The third occurrence included the suffocation deaths of a family of five in their Baldia area home. According to the newspaper report, tragedy struck when a family of four left their generator running overnight, leading to fatal gas poisoning [5].

Gas reportedly entered the office of Sui Southern Gas Company (SSGC) near the Eastern Bypass in Quetta, Pakistan, leading to an explosion that day, killing a little child and wounding six persons (including a woman)[6]. One official had serious burns in the subsequent firestorm caused by the explosion. Seven rooms were destroyed in the officers' mess when the bomb went off. The second blast occurred in the Wali Khan Chowk locality of Pashtunabad when a heater was accidentally left on. A woman and her five children were among the injured, and a teenage girl was killed.

The aforementioned events are representative of the many accidents that take place on a daily basis in Pakistan. Media outlets never report that carbon dioxide may make you dizzy or that carbon monoxide can be fatally silent. These mishaps could be avoided if these gases could be identified before they caused dizziness or damage. A recent study also indicated that most housing societies in Pakistan lacked gas safety precaution criteria in their construction bye laws, which further supports our belief that this system should be in every house. Therefore, it is critical to develop a small, portable electronic device capable of detecting and identifying the vast majority of hazardous gases that could be present in a house as a result of a leak or other malfunction.

1.5 Objectives

- The main objective of these Networks is to record the concentration levels of atmospheric pollutants in order to define air quality levels and establish action plans if high levels of contamination are detected.
- Obtaining the necessary information to define Action Plans as stipulated by European directives or other international regulations if alert thresholds are breached.
- Informing citizens regarding local air quality status.
- To make short-term (1 – 5 days) prediction

1.6 Scope

- Apart from its low cost and low power consumption, it takes less space and can be installed anywhere and provide operational efficiency and flexibility than traditional wired methods.
- The proposed system measures the air quality of a particular area with the help of the hardware module fixed at certain locations like lamp posts.

- Although there are a huge number of existing systems, the proposed system provides a unique feature by transmitting calculated information for traffic control purposes if air quality is detrimental.
- The additional benefit of the proposed system is the mobile application

1.7 Deliverables

The Project is a combination of two parts hardware and software.

1.7.1 Hawk Eye

1.7.1.1 Hardware Part

The Hardware part contains

- PCB designing
- Integration of circuit with WI-FI
- Displaying of data on LCD screen

1.7.1.2 Software Part

The Software part contains

- Integration of data on web page (Fire base real time data)
- Real time data on application

1.8 Relevant Sustainable Development Goals

Efforts to combat air pollution will contribute to **SDG 3 (good health and well-being)**, SDG target 7.2 on access to clean energy in the home, SDG target 11.6 on air quality in cities, SDG target 11.2 on access to sustainable transport and SDG 13 (climate action), as well as the goals of the Paris Agreement on climate
The SDG framework has a total of 17 goals, 169 targets and 244 indicators— **93 of which are environment related**. The SDGs aim to measure the most pressing issues facing the planet, including the interactions between topics.

1.9 Structure Of Thesis

Chapter 2 contains the literature review.

Chapter 3 Overview of the harmful gases and environment.

Chapter 4 contains the design and development of the project..

Chapter 5 Components used in project.

Chapter 6 highlights the use of WI-FI.

Chapter 7 highlights the importance in future

CHAPTER 2

LITERATURE REVIEW

2.1 Contextualization

We will begin by discussing the many different types of gas sensors and their fundamental functions. In depth descriptions of the sensor type used, its functioning, and its component parts are provided.

The electronic   is explored in further depth towards the chapter's conclusion.

2.2 Gas Detection Equipment

Gas measurement is important in many facets of life and work. Due to increased international environmental and safety standards and a heightened awareness of the need to protect the environment, the reliable detection of harmful, destructive, or lethal gases has become a pressing issue in the recent decade. Single gas sensors can be used for many purposes, such as detecting fires and leaks, controlling ventilation in vehicles and aeroplanes, and setting off alarms when dangerous levels of gas are present in the workplace. Because of this, multisensor systems (sometimes called electronic s) are being used more often in the food business and in the investigation of indoor air quality to examine these complex environmental mixtures.

The greatest hope for the commercialization of gas sensors for a broad variety of such applications is the development of solid state gas sensors, which may be based on a number of concepts and materials. Small in size, very sensitive to detect extremely low concentrations (at level of ppm or even ppb), possibility for on-line operation, and cheap cost owing to feasible bench manufacture make solid state gas sensors of tremendous interest to the industrial and scientific sectors. Traditional analytical instruments, such as mass spectrometers, nuclear magnetic resonance (NMR) scanners, and chromatographs, have the disadvantages of being both costly and space-consuming. The necessity for sample preparation in the vast majority of investigations precludes their online, real-time analysis.

Multiple physical processes are required for solid-state sensors to detect gases. In contrast to optical methods, which rely on the infrared absorption of gases, chemical approaches detect the gas by a specific chemical reaction with a reagent, and these methods frequently employ solid-state chemical detection principles. The two-fold nature of the gas's interaction with the solid-state material's surface is what sets solid-state gas sensors apart from other types of gas sensors. The reaction may be detected in a number of ways than just measuring the conductivity of the gas-sensing material as it changes; such methods include measuring the changes in capacitance, work function, mass, optical features, or reaction energy. These gas sensing devices may have active layers made from thin or thick films of organic (conducting polymers, porphyrins, and phtalocyanines) or inorganic (semiconducting metal oxides) materials. Electrodes, diode arrangements, transistors, surface wave components, thickness mode transducers, and optical setups are only some of the technologies that may be used to read out the observed value. Solid-state gas sensors are used in the same manner regardless of whether specific technology is used to implement the same fundamentals. This has led to the availability of a wide variety of solid-state gas sensors. The wide diversity of sensors now in use need a complex network of multidisciplinary study [7] to manage current gas-sensing systems. Here is a brief summary of the different types of current solid-state gas sensors.

In Table 2-1 below, we compare the different solid-state gas sensors and the physical change they use to detect gas.

Type of Gas sensors	**Physical change**
Semiconductor gas sensors	Electrical conductivity
Field effect gas sensors	Work function (electrical polarisation)
Piezoelectric sensors	Mass
Optical sensors	Optical parameters: surface plasmon resonance, reflection, interferometry, absorption, fluorescence, refractive index or optical path length
Catalytic gas sensors	Heat or temperature
Electrochemical gas sensors	Electromotive force or electrical current

2.2.1 Gas Sensing Devices Relying on Semiconductors

In order to detect gases, chemoresistive gas sensors (SGS) often use a metal oxide (such as SnO2, TiO2, In2O3, WO3, NiO, etc.) as their bas1e material. Metal oxide (semiconductor) gas sensors measure the electrical conductivity of the gas. When exposed to the desired gas, their active sensor layer experiences a change in resistance. In an ideal scenario, the gas would have a reversible interaction with the sensor surface.

2.2.2 Gas-Measuring Field-Effect Sensors

Gases create a field effect in MOSFET (metal oxide semiconductor field-effect transistor) devices, which are used in field effect sensors. Charges from gas molecules on the gate contact alter the sensor's output voltage. The voltage at the gate contact is raised when gases react with the catalytic gate metal, inducing dipoles or charges. Gas response selectivity is affected by temperature, gate metal, and gate metal structure.

Chemical reactions may take place in a few of milliseconds. The catalytic metal retains its purity despite extensive environmental contamination [9].

2.2.3 Gas Sensing Piezoelectric Transducers

A piezoelectric sensor must convert the physical values into an electrical charge in order to measure pressure, acceleration, strain, or force [11]. This is done by taking advantage of the piezoelectric effect, which occurs when certain solid materials are subjected to mechanical stress.

2.2.3.1 QMB is a quartz-crystal microbalance

QMBs use the shift in frequency of a resonating quartz crystal to calculate mass per unit area. Tiny changes in mass, such as those caused by oxide growth/decay or film deposition on an acoustic resonator's surface, can throw off the resonance [12].

2.2.3.2 Gas Sensors Utilising SAW Technology

An electric field is oscillated to generate a mechanical wave, which travels through the substrate and is then transformed back into an electric field for analysis in piezoelectric acoustic wave sensors [13].

2.2.3.3 Microcantilever Gas Detection Sensors

As their bending or vibrational frequency can be monitored by a microcantilever sensor, cantilevers (protruding structures like beams that are supported at one end and carry a load at the other end or along their length) can be used as physical, chemical, or biological sensors. The analyte, or substance being analysed, is absorbed at a specified concentration, at which point its velocity changes. [14]

2.2.4 Light-dependent detectors

Optical gas sensors are a crucial sensing technology for monitoring a wide variety of chemical and biological compounds. Absorption spectral shifts were the original basis for optical chemical sensors. Elipsometry, spectroscopy (luminescence, phosphorescence, fluorescence, Raman), interferometry (white light interferometry, modal interferometry in optical waveguide structures), spectroscopy of guided modes in optical waveguide structures (grating coupler, resonant mirror), and surface plasmon resonance (SPR), in which the oscillation of electrons modifies the object, are all methods currently used in chemical sensors and biosensors. These sensors use the refractive index, absorbance, and fluorescence of analyte molecules to calculate concentration [7].

2.2.5 Gas Detection Sensors Based on Catalysis

Wheatstone Bridge circuits are used in catalytic detectors to convert the temperature increase caused by the oxidation of a gas into a sensor signal that is directly proportional to the gas concentration. An active heating coil and a reference heating coil are electrical components of the sensor. The catalyst itself contains the active ingredient. An exothermic reaction happens when combustible gases react with oxygen in the air, causing the temperature in the vicinity of the catalyst to rise. The outcome is that the adversaries will adjust their strategy.

To protect the sensors' temperature from the effects of environmental variations, an inert reference element is used to provide a steady baseline signal that is unaffected by gas.[15].

2.2.6 Electrochemical Gas Sensors, Version

Electrochemical sensors have been used for oxygen detection since the 1950s. In recent years, cutting-edge novel electrochemical sensors have been created in response to OSHA regulations demanding the monitoring of hazardous and flammable gases in confined space applications.

Miniaturised electrochemical sensors with high sensitivity and selectivity for a wide range of toxic gases in the PEL range have been commercially available since the mid-1980s. Numerous types of electrochemical sensors are now commonplace in both fixed and mobile monitoring infrastructures. It is possible to see working examples of the electrochemical sensors shown in Figure 2-1.

Figure 2-a ***Electrochemical Sensors***

The function for which an electrochemical sensor was designed usually dictates its form factor, material composition, and structural details.

The operation of electrochemical sensors is poorly understood by many. Electrochemical sensors used to detect different gases have different purposes, despite their similarity in appearance. What this implies is that the sensitivity, selectivity, reaction time, and longevity of individual sensors may be somewhat different. A low-concentration gas sensor, for instance, may benefit from a hydrophobic membrane with larger pores and a capillary with less limitations. Water molecules from the electrolyte are discharged into the atmosphere in greater numbers due to this design. High-sensitivity electrochemical sensors would have a limited lifetime due to water loss through the membrane.

The chemical reactivity of the target gas is also considered while making decisions about the electrolyte composition and the sensing electrode material. Selectivity towards the target gas may be accomplished by selecting an appropriate electrolyte and/or sensing electrode, however this may come at the expense of sensitivity.

In conclusion, it's vital to bear in mind that despite superficial similarities, distinct types of electrochemical sensors are made from a wide variety of materials. Some electrochemical sensors require more power to complete the reaction with the target gas. The sensors' total performance is highly dependent on the high quality of its individual parts.

2.2.6.1 Working Hypothesis

An electrochemical sensor may measure the target gas's concentration by converting a chemical reaction into an electric current. Electrochemical sensors, like the one seen in Figure 2-2, have two electrodes separated by an electrolyte: a sensing electrode (or working electrode) and a counter electrode.

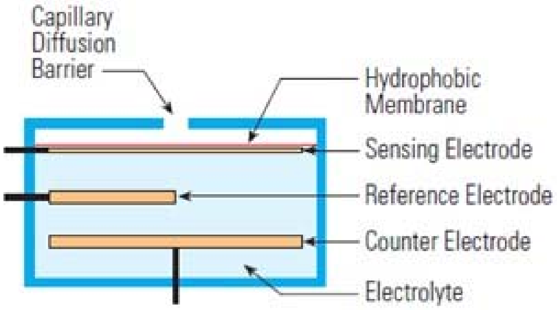

Figure 2-b ***Typical Electrochemical Sensor Setup***

A hydrophobic barrier separates the sensor's electrode surface from the gas that enters it through a tiny capillary-like aperture. This method, as shown in Figure 2-3, is used to keep the electrolyte within the sensor while yet allowing enough gas to react at the sensing electrode.

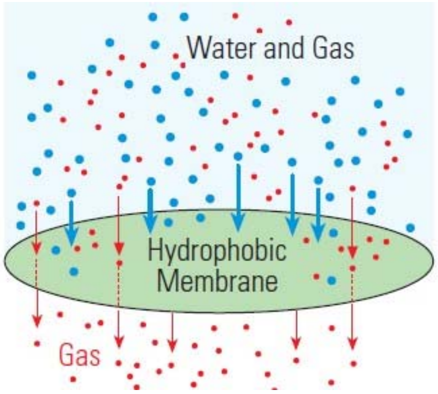

Figure 2-b ***The hydrophobic barrier effectively blocks the passage of water***

What happens at the sensing electrode's surface depends on whether the gas that penetrates the barrier is oxidised or reduced. Electrode materials designed for this purpose act as catalysts for these reactions. By connecting a resistor in series with the cell's electrodes, we may measure the gas concentration by measuring the cell's current output. The concentration of the gas may be detected by measuring the current.

2.2.6.2 What the Reference Electrode Is and How It Works

When supplied by an external voltage, a sensor can only operate properly if the potential at the sensing electrode remains unchanged. The voltage at the sensing electrode changes over time as a consequence of electrochemical processes taking place on its surface. When exposed to light, the sensor's performance declines over time. Including a reference electrode boosts the sensor's functionality. To provide a point of comparison, this electrode is submerged in the electrolyte adjacent to the sensing electrode. The sensor electrode is subjected to a continuous voltage. The sensing electrode's voltage is maintained at a constant level by the reference electrode. No current is being produced or consumed at the reference electrode. The concentration of a gas may be estimated by reacting molecules at a sensing electrode and then monitoring the current between a detecting and counter electrode. The sensor electrode's sensitivity is tuned for the desired gas by a voltage supplied to it.

2.2.6.3 Essential Elements

These parts make up the bulk of any electrochemical sensor:

2.2.6.3.1 A Membrane that Allows Gases to Pass But Not Water

To prevent gas molecules from reaching the sensor's detecting (catalytic) electrode, this component is essential. Thin and impermeable Teflon membranes are often used to construct such a wall. A sensor protected by a membrane is an example of this category of devices.
The flow of gas to the electrode surface may be regulated using capillaries or Teflon coatings on sensing electrodes. A capillary sensor is an example of this kind of device. The membrane serves as a filter, preventing dust and other particles from reaching the sensor while also shielding it from damage. Choosing a membrane and capillary with the right pore size is crucial for allowing the required number of gas molecules to pass through. The number of gas molecules that can flow through the pore and onto the detecting electrode is a key consideration in pore design. The sensor's pore size has to be optimal so that it doesn't lose its liquid electrolyte too rapidly.

2.2.6.3.2 Indicator Electrode

Electrode material must be carefully selected. This catalysed substance allows the half-cell reaction to be maintained for very extended periods of time. Electrodes consisting of noble metals like platinum or gold are often treated with a catalyst to facilitate a highly reactive interaction with gas molecules. All three electrodes may be made of different materials to provide a full cell response, depending on the sensor's design.

2.2.6.3.3 The Electoral College System

The electrolyte's primary functions are to transport ions between electrodes and to facilitate the cellular response. In addition to coordinating with the sensor's constituent parts, it must provide a constant reference voltage at the reference electrode. The sensor's signal will degrade if the electrolyte evaporates too rapidly.

2.2.6.3.4 To What Extent Does the Filter

Scrubber filters are sometimes used to purify the air before it reaches the sensor. Filters are few, and those that are available have significantly varying capacities. Activated charcoal is the most prevalent kind of filter media, as seen in Figure. Carbon monoxide and hydrogen are two gases that might pass through the activated charcoal filter. With the proper filter media, electrochemical sensors with selectivity are feasible.

Finding the optimal materials for these parts and the appropriate shape for combining them for maximum performance is a significant problem for scientists. Sensor robustness, precision, responsiveness, sensitivity, and selectivity are all very sensitive to seemingly inconsequential design choices.

2.2.6.4 The Role of Oxygen in Living Things

The anode (sensing electrode) participates in the interactions with the gases in the following ways:

For CO2

$CO_2 + H_2O = CO_2 + 2H^+ + 2e^-$

Sulfuric acid

$H_2S + 4H_2O = H_2SO_4 + 8H^+ + 8e^-$.

Oxygen molecules

It is also required for the processes taking place at the cathode, sometimes known as the counter electrode.

$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

If there isn't enough oxygen, the sensors won't function properly or last as long. Water is a byproduct of gas sensors that reduce the gas at the cathode, such as those used to detect nitrogen dioxide, chlorine, and ozone. Water undergoes synchronous oxidation at the anode [16].

2.3 Electrified Gadget

2.3.1 Aroma's Function in Everyday Life and the Workplace

The sense of smell has historically been crucial to human growth and communication with the natural world. As a result, the olfactory sense has been instrumental in the growth of a wide range of commercial sectors, which now routinely alter the aroma properties of their manufactured goods to improve product appeal, quality, and consistency, and to enable customers to readily recognise and favour particular brands based on their distinctive aromas. Industrial production and commercial trade rely heavily on olfactory features, such as the bouquet of wines and meals, the odours added to personal health care goods, and the aromas featured on product packaging. Spices, in the same vein, have been used for centuries as both flavour enhancers in cooking and potpourri-style air fresheners. Throughout history, spices have played a pivotal role, frequently serving as a pretext for the establishment of brand-new commercial trade routes around the globe. Customers' willingness to pay is, thus, primarily determined by olfactory attributes, which have greatly boosted the worth and attractiveness of many commercial objects. As a result, maintaining product consistency is vital for consumer brand recognition and satisfaction, making research and quality control of fragrance characteristics during manufacturing of goods of key relevance in industrial production processes. Numerous studies have shown that alterations to the manufacturing process that alter a product's aroma or flavour can have a devastating effect on sales and market share.

The olfactory system is vital to humans, however the is often seen as the least developed and acute sense. Dogs have around 100 million fragrance receptors, allowing them to discriminate odours at least 100 times more efficiently than the typical human. Humans only have roughly a million fragrance receptors that work together to process olfactory information. The ability to sense chemicals is crucial to the survival of both prokaryotic and eukaryotic organisms. Evidence for the relevance of olfactory systems in higher eukaryotes includes the fact that up to 4% of the genome is allocated to encoding products needed in the creation of olfactory sensory tissues. Electronic equipment with sensors capable of performing such discriminations with high precision is required since the human has relatively limited sensitivity and discrimination abilities and may quickly grow weary after repeated discriminations. However, people have historically lacked the vocabulary to precisely describe smells and evaluate them in more specific, consistent ways, despite the fact that the olfactory sense has long been linked to human emotion and the love of beauty. Prior to this discovery, aromatic compounds could only be characterised by their proximity to other chemicals. In order to more precisely quantify and express the aroma characteristics of volatile organic compounds (VOCs) released as mixtures from specific source types, methods and instruments capable of recording unique quantitative and qualitative measurements of headspace volatiles derived from known sources have had to be developed. Because of these factors, researchers have worked hard to create electrochemical sensors sensitive enough to pick up on the odours of complicated vapour combinations.

2.3.2 The Rise of the "Electronic "

The first gas multisensor array was developed in 1982, marking the beginning of the sensor era in artificial olfaction. Recent developments in aroma-sensor technology, electronics, biology, and artificial intelligence have made it possible to develop instruments that can identify, measure, and analyse the ephemeral odours emitted by a wide variety of modern sources. In order to identify and categorise fragrance mixes without tiring out human operators, technology has been developed to mimic the mammalian olfactory system. When it comes to analytical tools, none compare to those that can single out a specific chemical species from a complex mixture of organic chemicals (and hence the source from which the mixture was released). The detection of VOCs in different gaseous vapour mixtures has led to the development of artificial prototypes. Electronic aroma detection (EAD) systems make use of a wide variety of sensors, from metal-oxide detectors to semi-conductive polymers and conductive electro-active polymers to optical, surface acoustic wave, and electrochemical gas detectors.

Electronics are powered by a data processor (often an ANN), digital pattern-recognition software, and a reference information database, in addition to the myriad of sensors that are used to gather data. The cross-reactive sensor array is made up of sensors that are somewhat different from one another, allowing it to detect a large variety of compounds and separate individual analytes from complex combinations. Multiple sensor readings can be combined into one innovative digital response pattern.

A "scent signature," often called a "electronic fingerprint," is a distinctive pattern of sensor responses that may be used to identify and categorise a specific analyte combination. No matter how basic or complicated the combination is, its olfactory signature pattern may be used to uniquely identify it. Building a library of digital fragrance signature patterns from known samples facilitates the investigation of unknowns. The ANN is trained to classify analytes by comparing their patterns to those in a library of known examples. This procedure is repeated until the desired length is achieved. A database of reference samples is then constructed using the verified data. The distribution of the analyte's fragrance qualities or components may be compared to the distributions in the databases of the reference library, where the unknowns may be located.

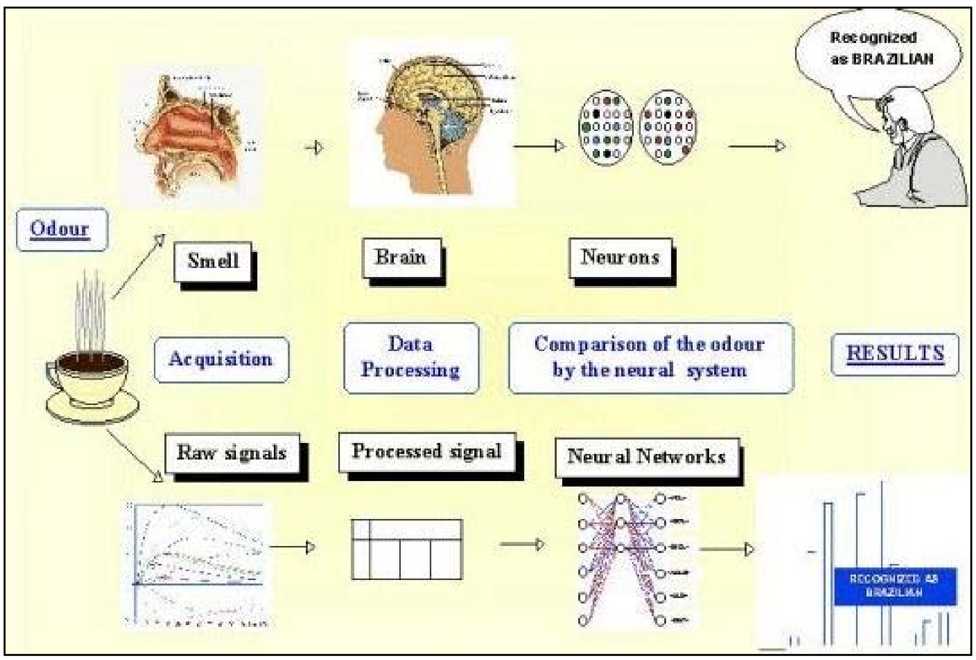

Figure 2-c ***Signals are detected using both the human brain and an electronic***

So far, EAD technology has mainly found use in the manufacturing, processing, and production sectors. Quality control testing, process regulation, gas leak detection, and inspection of waste water and byproducts are all commonplace in the manufacturing industry. Assessments of volatile emissions, homeland security, environmental protection, biological diagnostics, worker safety, and product development are only some of the new areas where applications are being created. [18]

Due to the discovery of many applications stemming from research in a variety of applied sciences, electronic nasal devices have gained a lot of interest in the sensor technology sector during the last two decades. Recent developments in sensor design, material improvements, software breakthroughs, micro-circuitry design, and systems integration may explain the widespread use of electronic technologies. Different types of e sensors and arrays, each with its own particular means of detection, are being developed as new applications arise. There are a wide variety of sectors that have benefited greatly from the implementation of electronic s, including agriculture, biomedicine, cosmetics, the environment, food, manufacturing, the military, pharmaceuticals, regulatory agencies, and a wide variety of scientific research disciplines. Electronic- monitoring has improved product characteristics, homogeneity, and consistency throughout all stages of industrial production [17].

2.4 In Brief

In conclusion, this article has offered a survey of Gas sensors. Six different kinds of gas sensors were reviewed, and their inner workings and necessary components were described in detail. The article also covered the history and thought processes of Electronic .

CHAPTER 3

Causes and Effects of Gases

3.1 Overview

Even in the comfort of our own homes, we may be exposed to harmful levels of indoor air pollution. Indoor pollution sources, such as those that release gases and particles, are the principal culprits in creating unhealthy air quality in residential settings. The amount and concentration of emissions of the pollutant in issue are used to rank the sources in order of significance.

Some people may have acute symptoms from inhaling contaminated indoor air, while others may not feel the consequences for years. Long-term dwellers in polluted indoor environments are also at greater risk for developing health problems. The elderly, the very young, and individuals with long-term health issues like asthma or cardiovascular disease all fall into this category.

3.2 The Origins of Gases

3.2.1 CO2 (Carbon Monoxide): A Gaseous Element

Both natural and human-caused activities may contribute to atmospheric concentrations of carbon dioxide. Human-made sources include cement manufacturing, deforestation, and the combustion of fossil fuels like coal, oil, and natural gas, whereas natural sources include decomposition, ocean discharge, and respiration.

As a result of human activity throughout the Industrial Revolution, atmospheric carbon-dioxide levels have grown substantially, reaching dangerously high levels not seen in the preceding 3 million years. While natural emissions of carbon dioxide are significantly greater, the natural equilibrium that existed for thousands of years prior to human involvement has been disrupted by human activity. This is because the quantity of CO_2 being absorbed by natural sinks is about equivalent to the amount being produced by natural sources. Because of this, carbon dioxide levels remained constant and far below acceptable thresholds. However, human-caused emissions have disrupted this equilibrium by raising carbon dioxide levels without correspondingly decreasing oxygen levels in the atmosphere.

3.2.1.1 Human Resources

Human activities have increased in importance as a cause of global warming since the Industrial Revolution. Rising atmospheric carbon-dioxide levels are mostly caused by human activities like burning oil, coal, and gas and reducing forest cover.

When fossil fuels like coal, natural gas, or oil are burned, carbon dioxide is discharged into the air. Four percent comes from cement manufacture and other industrial activities, nine percent from deforestation and other land use changes, and one percent from other causes.

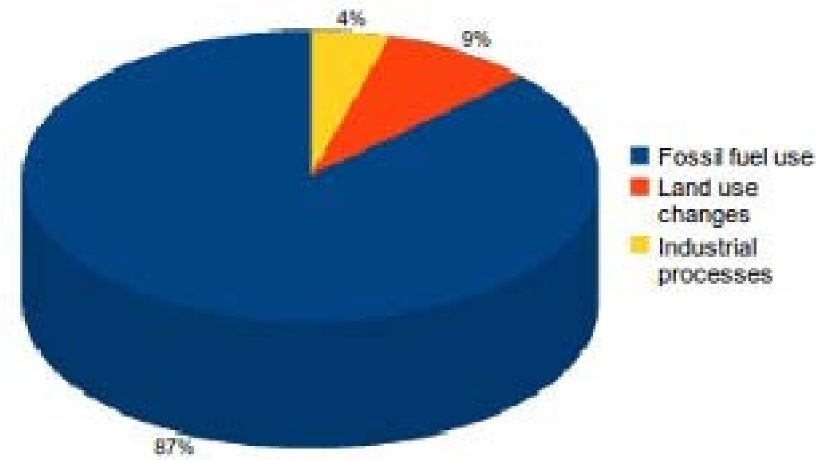

Figure 3-a ***Sources of CO2 Emissions Caused by Human Activity***.

3.2.1.1.1 Burning and Using Fossil Fuels

Human-caused carbon dioxide emissions are mostly attributable to the burning of fossil fuels. This accounts for more than 87% of total carbon dioxide emissions. These fuels are used to power everything from homes to cars. Their applications range from the energy industry to transportation to the aerospace industry to general manufacturing. The use of fossil fuels led to an all-time high of 33.2 billion metric tonnes of carbon dioxide being released into the atmosphere in 2011.

Coal, natural gas, and oil are the three most widely used fossil fuels. Fourty-three percent of all carbon dioxide emissions come from coal, 36 percent from oil, and 20 percent from natural gas. The carbon intensity of coal is the highest among fossil fuels. About 2.5 tonnes of carbon dioxide are released into the atmosphere whenever 1 tonne of coal is burned. Coal is the most carbon dioxide (CO_2)-intensive fossil fuel. Most greenhouse gas emissions come from burning coal, which is also the most widely used fossil fuel. Coal provides just 43% of the world's major energy supply, but produces 13% of all fossil fuel emissions.

Electricity/heat generation, transportation, and industrial production are the three largest consumers of fossil fuels. About two-thirds of the world's carbon dioxide emissions came from the first two categories in 2010 (electricity/heat production and transportation).

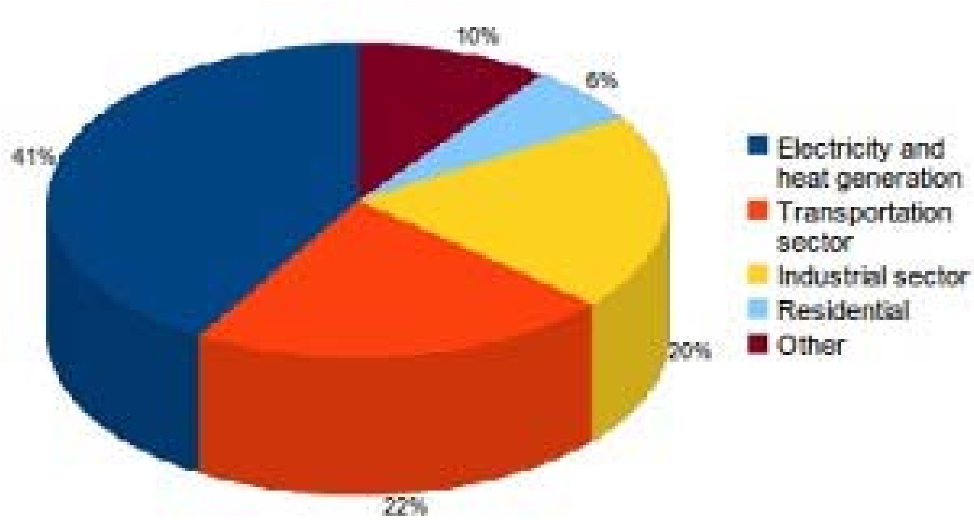

Figure 3-b ***Emissions of Carbon Dioxide from the Burning of Fossil Fuels.***

3.2.1.1.1.1 Producing Both Electricity and Heat

Burning fossil fuels for energy and heat production is the main contributor to manmade carbon dioxide emissions. In 2010, 41% of all global carbon dioxide emissions originated from the combustion of fossil fuels. Since coal is the most carbon-intensive fossil fuel, this company's impact on the environment is substantial.

The majority of the power in industrialised countries comes from the combustion of fossil fuels (60%-90%). The only two nations that don't follow this rule are Canada and France.

Ninety-two percent of all power use comes from just three sectors: industry, homes, and businesses. High energy requirements of certain manufacturing processes account for the majority of industrial consumption. Most electricity is used in the manufacturing of chemicals, metals and metal products, construction materials, cement, aluminium, and paper and paper products. Lighting, heating, cooling, and appliance usage are just some of the many building functions that rely on electricity.

3.2.1.1.1.2 The Transportation Industry

The transportation industry is responsible for 2% of all global warming gases released into the atmosphere. Twenty-two percent of the world's carbon dioxide emissions in 2010 came from the transportation sector due to the burning of fossil fuels. This industry is characterised by its high energy use and dependence on fossil fuels (gasoline, diesel, kerosene, etc.). Since the 1990s, the transport industry has been responsible for 45% of all emissions.

The majority of the nation's carbon dioxide emissions come from the transportation sector, particularly roads and highways. Cars, goods, and light-duty vehicles are the main contributors to the rapid increase in transportation-related emissions since 1990. In addition to automobiles on the road, pollution in this sector is also significantly impacted by ships on the sea and international aircraft.

One-fourth of all carbon dioxide emissions from transportation come from the maritime industry. Crude oil that is still liquid when walked on is burned aboard ships, making them the dirtiest vehicles on the road while being far less prevalent than automobiles. That means that annually, shipping accounts for more than a billion tonnes of carbon dioxide. Many industrialised countries (including Germany, South Korea, Canada, the United Kingdom, and many more) currently produce more greenhouse gases than rapidly expanding sectors like this one.

The aviation industry is responsible for just 0.1% of global transportation-related CO2 emissions. The majority of these emissions originate from international flights (62%), while domestic flights barely contribute (38%). Air travel's impact on global carbon dioxide emissions has grown dramatically during the last decade. Air travel is the kind of transportation that leaves the highest carbon footprint, hence its rapid expansion is a major contributor to global warming.

Since the consumer has no control over how far the goods must travel from the factory to the retailer, transportation-related emissions are an example of indirect emissions. Emissions from transportation modes such as automobiles, aircraft, trains, etc. are considered direct emissions since individuals may choose where to go and how to get there.

As the transportation sector struggles to keep up with the increasing distances commodities must travel during production, indirect emissions increase. Carbon dioxide emissions from global shipping are mostly attributable to the combustion of fossil fuels.

3.2.1.1.1.3 Manufacturing and Production

Production facilities are responsible for just 3% of industrial CO2 emissions worldwide. Twenty percent of the world's carbon dioxide emissions in 2010 came from the combustion of fossil fuels. The term "industrial" may refer to a wide range of businesses, from factories to mines to farms. Paper, food, petroleum refining, chemicals, and metals and minerals all go under manufacturing, the biggest of the four industries. These companies account for the great bulk of the industry's use of fossil fuels and production of carbon dioxide.

Industrial and manufacturing activities result in substantial emissions of carbon dioxide and other greenhouse gases. This is due to the fact that fossil fuels are used to generate heat and steam for a variety of industrial processes. Cement plants, for instance, use fossil fuels to generate heat to transform limestone into cement at temperatures of 1450 degrees Celsius.

3.2.1.1.2 Substantial Modifications to Existing Land Use

Land use changes contributed to the emission of 3.3 billion metric tonnes of carbon dioxide into the atmosphere in 2011. This is responsible for 9% of all human-caused carbon dioxide emissions. When formerly unoccupied lands are settled by people, a shift in land use has occurred. Land use and land use change were responsible for between 28% to 40% of all anthropogenic carbon-dioxide emissions between 1850 and 2000.

It's possible that deforestation is the primary cause of these emissions. Deforestation is the most notable land use change in terms of its effect on greenhouse gas emissions. In many places, trees have been cut down and burned to make way for pastures and farms. There are three mechanisms via which deforestation increases atmospheric carbon dioxide level

Plants absorb CO_2 from the atmosphere and store it for future use. They are able to do this by absorbing carbon dioxide from the atmosphere during photosynthesis. Carbon dioxide is emitted into the atmosphere whenever trees are burnt or decayed during forest clearing for agricultural use.

Deforestation causes forests to lose ground, reducing the number of trees available to take up carbon dioxide. Some carbon dioxide can be removed from the air by crops produced in treeless areas, although at a considerably slower pace than forests did before they were cut down.

Even though the carbon stored in trees that are cut down for their timber is not lost, the carbon sink that forests provide is diminished.

The soil's ability to retain carbon is also greatly diminished by deforestation. Both enhanced rates of decomposition in converted soils and soil disturbance contribute to carbon dioxide emissions during forest clearance. The area's capacity to act as a carbon sink is diminished because of the resulting increased soil erosion and nutrient leaching.

3.2.1.1.3 Manufacturing Techniques

Carbon dioxide is released into the atmosphere via two different combustion processes using fossil fuels: direct combustion and indirect combustion to create energy. Making and utilising cement and other mineral products, metals like iron and steel, and chemicals and petrochemical goods are all examples of industrial activities that produce significant amounts of carbon dioxide.

The production of cement accounts for a disproportionate share of the world's industrial carbon dioxide emissions. Calcium oxide, the main component of cement, is a chemical byproduct of the heating of limestone. As a consequence of the chemical reaction, significant amounts of carbon dioxide are released. It is correct that generating one thousand kilogrammes of cement requires around 900 kilogrammes of carbon dioxide.

Carbon dioxide levels in the atmosphere are also significantly affected by the steel industry. To make steel, iron is melted and processed to remove impurities, mostly carbon. During this process, carbon from the iron combines with oxygen to produce carbon dioxide. Every tonne of steel produced leads in the release of around 1.9 metric tonnes of carbon dioxide.

The production of chemical and petrochemical products from fossil fuels results in atmospheric emissions of carbon dioxide. Manufacturing ammonia and hydrogen from natural gas or other fossil fuels results in the byproduct of carbon dioxide. Products like plastics, cleaning supplies, and lubricants may all benefit from petrochemicals, which are derived from petroleum. Carbon dioxide is released as a consequence of the gradual breakdown of these molecules due to evaporation, dissolution, or wear.

3.2.1.2 Organic Materials

Both natural and human-caused processes contribute significantly to the amount of carbon dioxide in the air. Natural carbon dioxide emission occurs in the seas, soil, plants, animals, and volcanoes. Small as human-caused carbon dioxide emissions are in comparison to natural emissions, they are still enough to disrupt the pre-Industrial Revolution carbon cycle. For aeons, natural carbon sinks have kept atmospheric CO_2 levels steady, exactly offsetting emissions from natural sources. As a result of this natural equilibrium, atmospheric carbon dioxide levels were largely steady prior to human involvement.

Ocean-atmosphere interaction is the single largest contributor to natural CO2 emissions (42.84%). The respiration and decomposition of soil and plant and animal matter also contribute significantly to the natural atmosphere (28.56%). Volcanic eruptions provide only 0.03 percent.

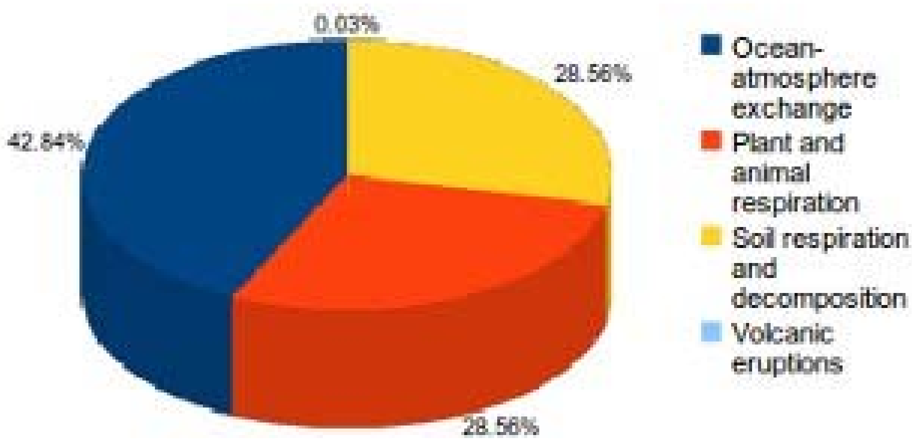

Figure 3-c ***Carbon Dioxide from Natural Sources.***

3.2.1.2.1 Ocean-Atmosphere Interaction, Version

The interaction between the ocean and the atmosphere is the primary natural source of carbon dioxide emissions. This activity accounts for 42.84 percent of total atmospheric carbon dioxide emissions. Carbon dioxide that has been dissolved in water is released by the seas. More than 330 gigatons of carbon dioxide are released into the atmosphere every year due to this procedure.

Carbon-dioxide is only one of several compounds that might escape into the air through diffusion from the water. Oceans act as both a source and sink for atmospheric carbon dioxide. The gases in water will escape and form air bubbles if you leave some water in a glass for a while. These spaces contain a variety of gases, including carbon dioxide.

3.2.1.2.2 Respiration of Animals and Plants

Respiration from plants and animals is a major source of atmospheric CO2, accounting for 28.56 percent of all natural emissions. Photosynthesis, the chemical process through which plants and animals get energy, produces carbon dioxide as a waste product. Carbon dioxide emissions from this process are estimated at over 220 billion metric tonnes annually.

Respiration is the primary source of energy for all living things, and this fuels vital processes including development and movement. Oxygen is used in the metabolism of carbohydrates, proteins, and fats. In addition to producing water and carbon dioxide, this process may provide energy that the organism can utilise.

3.2.1.2.3 Decomposition and Combustion of Soil

Soil respiration and decomposition account for around 28.56 percent of global carbon dioxide emissions. Soil organisms mostly get their energy via respiration. Some of these organisms are decomposers, which eat decaying matter. The result of each of these processes is carbon dioxide. These soil organisms are responsible for around 220 gigatons of annual CO2 emissions.
To describe any kind of breathing in dirt, the phrase "soil respiration" is often used. This is a double-edged sword since carbon-dioxide is essential for the respiration of roots, bacteria, fungus, and soil animals. Subterranean decomposers play an important role in recycling organic matter such as dead trees, leaves, and animals. Decomposition is a potential source of carbon dioxide (CO2) emissions.

3.2.1.2.4 Eruptions of Volcanoes,

Volcanic eruptions are responsible for just 3% of the naturally occurring CO2 emissions. Magma, ash, dust, and gases seep out of the Earth's interior during volcanic eruptions. Carbon dioxide and other gases are examples of emissions. Carbon dioxide emissions from this process range from 0.15 to 0.26 billion metric tonnes per year.

Volcanoes typically release steam, carbon dioxide, and sulphur dioxide as their primary gases. Magma absorbs these gases as it moves through the Earth's mantle and crust, a process triggered by volcanic activity. After then, the gases escape during eruptions and enter the atmosphere [18].

3.2.2 Carbon monoxide (or CO)

Carbon monoxide may be introduced into a home by a number of different routes, including: backdrafting from gas appliances (such as water heaters, stoves and fireplaces); generators; gas appliances (such as stoves and dryers); charcoal barbecues; gasoline-powered tools; connected garage vehicle emissions; cigarette smoke; and so on. Incomplete oxidation during combustion is a potential source of indoor CO from gas ranges and unvented gas or kerosene heaters [19, 20]. It's possible that the exhaust from automobiles, trucks, and buses in nearby garages, on the streets, and in parking lots has a major impact [21]. As may outdated, improperly set, or otherwise neglected combustion equipment. Transportation, road vehicles, industry, and smelters all contribute significantly to atmospheric CO2 levels [22].

3.2.3 CH4 or methane

Methane emissions are affected by both natural and anthropogenic causes. Wetlands, termites, and the seas are the three main contributors from nature. Human activity accounts for just 36% of methane emissions. Landfills, animal husbandry, and the manufacture, transportation, and combustion of fossil fuels are the most significant human contributors. The majority of the world's methane emissions (64.5%) are caused by human activities. More human-caused methane emissions sources have come online since the start of the Industrial Revolution.

3.2.3.1 Human Resources

Human activities such as the extraction of fossil fuels and the intensive farming of livestock are key contributors to the increase in atmospheric methane. Sixty percent of all human-caused methane emissions come from these two places. Sixteen percent comes from landfills and garbage collection, eleven percent from biomass burning, nine percent from rice farming, and four percent from biofuels.

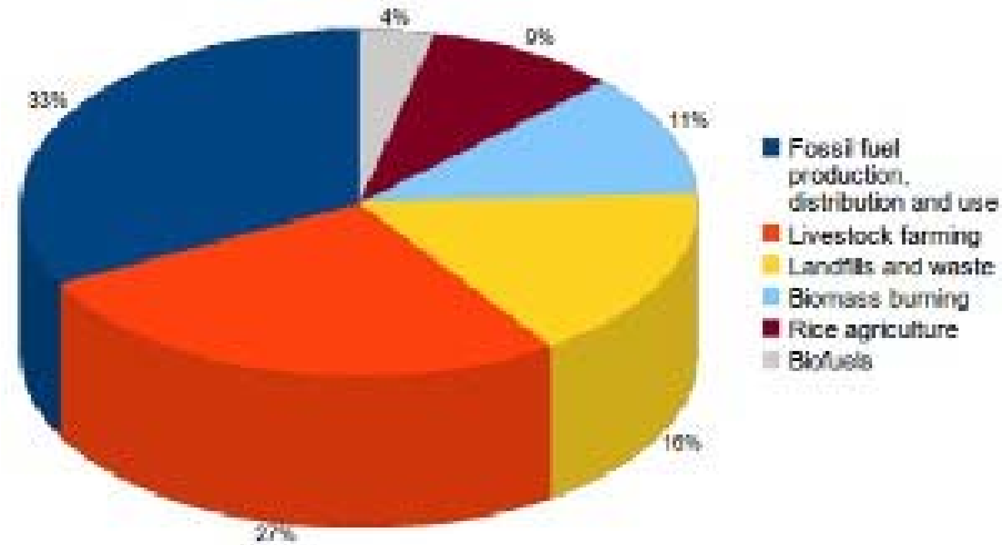

Figure 3-d ***The origin of synthetic methane.***

3.2.3.1.1 Use and Absorption of Fossil Fuels

The extraction, transportation, and combustion of fossil fuels account for the vast majority of human-caused methane emissions. This is the source of 33 percent of all human-made methane emissions.

When fossil fuels are burned, methane is released into the atmosphere. The extraction of natural gas (mostly methane), coal, and petroleum all contribute to pollution levels. The whole fossil fuel industry, from mining to pipelines to trucking to refining, contributes to methane emissions. When fossil fuels are burned, methane is created in trace amounts.

3.2.3.1.2 Pets and Other Animals

Animal enteric fermentation is a significant contributor to methane emissions. More than a quarter of all methane emissions come from this source. Ruminant animals, such as cows, sheep, and goats, produce a lot of methane as a waste product from their digestive systems. Methane is inhaled or exhaled by these animals because of enteric fermentation, which is triggered by bacteria in the stomach. It is presumed that human activity is responsible for these emissions since the animals are reared for human consumption. Meat consumption has a large impact on greenhouse gas emissions. About 90 million tonnes of methane are released into the atmosphere every year due to livestock farming.

3.2.3.1.3 Waste Management and Landfills

Although there are other significant sources, human activity accounts for the vast majority of atmospheric methane. Landfills are a major source of methane because of the decay of organic matter there. Both human and animal waste are included in this category. Only about 16% of the methane in the atmosphere comes from human activities. Annual methane emissions from landfills and similar rubbish dumps total 55 million tonnes.

Our garbage cans and landfills are overflowing because of our food scraps, newspapers, lawn clippings, and leaf litter. Garbage collects and is eventually stacked on top of older garbage. Landfills are hostile places where all living forms ultimately die from a lack of oxygen. When garbage is decomposed, these conditions are ideal for the growth of microbes that produce methane. Even long after a landfill is no longer accepting trash, microorganisms will be hard at work breaking down the buried trash and releasing methane.

Wastewater streams from households, towns, and industry are all potential sources of methane emissions. It is possible to dump, store, or treat wastewater as a means of disposal. When organic matter in wastewater undergoes anaerobic decomposition, methane is produced, just as it is in landfills.

3.2.3.1.4 Fires Powered by Biomass

Methane emissions increase significantly when biomass is used as fuel. Biomass is any material that was once a part of a living creature. Mass methane emissions are possible if biomass at this size is burned incompletely. About 10% of the global methane emissions come from this source.

Humans often use massive open fires for the purposes of disposing of agricultural waste and preparing ground for cultivation or other uses. Wildfires may occur for a variety of reasons, some of which are unavoidably natural, but most biomass fires are started by humans. It is predicted that 38 million tonnes of methane are released annually due to the combustion of biomass.

3.2.3.1.5 Agricultural Output: Rice

Rice cultivation is a major contributor to the release of this greenhouse gas due to human activity. Rice fields are sometimes compared as artificial marshes. Water and organic matter abound, but oxygen is scarce. As the organic matter decomposes, the bacteria present may be conducive to the production of methane.

Although most of the methane is vented into the atmosphere, some of it is used by bacteria as a fuel source. Rice production accounts for 9% of all human-caused methane emissions because of the moist and humid conditions needed for rice cultivation. Methane emissions from rice paddies total 31 million metric tonnes annually.

3.2.3.1.6 Biofuels

Twelve million metric tonnes of the strong greenhouse gas methane are produced yearly by biofuels. A biofuel is any renewable biological resource that may be used as a fuel. Methane is released into the atmosphere when biofuels are improperly burned. This contributes around 4% of the total human-made methane gas.

Open cooking fires, which use biofuels including wood, agricultural waste, and animal dung, account for more than 80% of all biofuel use. This is the main reason why biofuels contribute to pollution across the world. About 2.7 billion people get their daily energy needs met by solid biofuels for things like cooking and heating. Eighteen percent of biofuels are used by low-tech, generally unregulated micro-enterprises such as brick and tile producing kilns, restaurants, etc. The majority of their customers have modest incomes and reside in underdeveloped nations. Vehicles also use other types of biofuels,

3.2.3.2 origins of which are natural

The amount of methane in the air comes from a mix of natural and human-made sources. Natural sources of methane emission include wetlands, termites, and the ocean. For millions of years, natural methane sources and sinks have remained in balance. Before humans interfered, this natural equilibrium kept methane levels relatively stable. Human-caused methane emissions have disrupted the natural equilibrium that existed before the Industrial Revolution. The overwhelming majority (78%) of global natural methane emissions occur in wetland areas.

10% of the world's methane is found in the seas, while 12% is produced by termites.

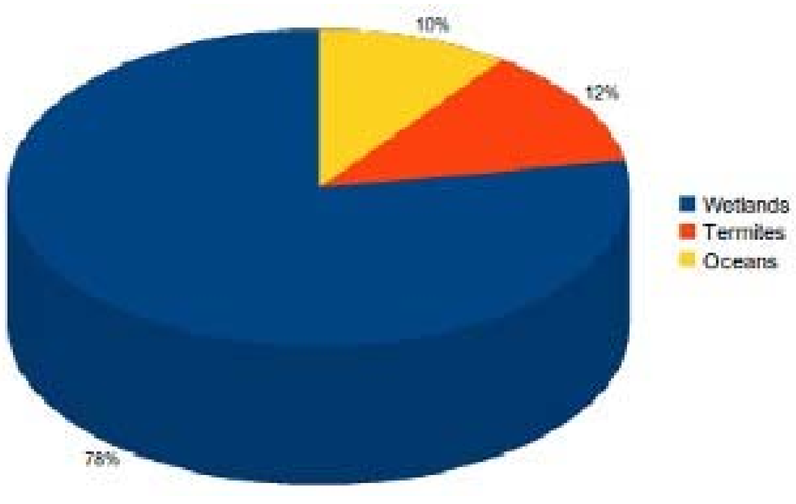

Figure 3-e ***The origins of methane gas***

3.2.3.2.1 The Waters Around Us

This gas is produced mostly by bacteria living in wetlands. As much as 78 percent of all methane emissions may be attributed to this process. Wetland habitats are ideal for bacteria that thrive in anaerobic, organically rich settings.

Although methane-eating microbes help reduce wetland emissions, a considerable amount still makes its way into the air.
About 147 million tonnes of methane are produced annually from wetlands.

3.2.3.2.2 An Overview of Termites

Methane gas is released into the atmosphere in large quantities by termites. Methane is a waste product of termites' digestion. Methane is produced by termites when cellulose is digested by the bacteria in their digestive tract. Twelve percent of the natural methane emissions worldwide come from this.

Methane emissions from a single active termite are negligible. However, extrapolating to the entire termite population, their annual methane emissions amount to 23 million tonnes.

3.2.3.2.3 Oceans

In addition, the seas create significant amounts of methane. This emission is caused by bacteria in the water decomposing organic materials. Ten percent of the world's methane emissions come from this source. Some 19 million tonnes of methane are released into the oceans every year.

Deeper sediment layers along economically active beaches are the primary source of methane emissions from the ocean. This is responsible for 75% of the marine methane emissions. Microbes produce methane, which reacts with water vapour at the ocean's surface and escapes into the air [23].

3.2.4 Sulfuryl Hydrogen Gas (H2S)

Both natural and manmade processes produce hydrogen sulphide. Crude oil, natural gas, salt marshes, sulphur springs, and wetlands are all examples of natural resources. Hydrogen sulphide concentrations as high as 42% have been found in certain natural gas reserves. Water treatment facilities, oil refineries, pulp and paper mills, landfills, and sewage disposal sites are all examples of industrial sources [24]. At high temperatures, the reaction of elemental sulphur or sulfur-containing compounds with organic molecules produces hydrogen sulphide. Several industries, including coke manufacturing, viscose rayon manufacturing, waste water treatment, sulfate-process wood pulp manufacturing, sulphur extraction, oil refining, and the tanning industry, all contribute to the generation of hydrogen sulphide [25]. Because of plumbing concerns, exposure is readily possible in the home. Hydrogen sulphide gas might leak into a residence if the traps in the pipes leading to the sewage are empty. Hydrogen sulphide gas may be dangerous to those who work with it in industries including animal husbandry, sewage treatment, and oil refining. The danger of inhaling in these chemicals is not limited to workers in the industries that manufacture them [26].

3.3 Gaseous Effects

3.3.1 Carbon-dioxide

The health effects of carbon-dioxide gas at different ppm is given below: [27-29]

Table 3-1: Effects and Symptoms of carbon-dioxide at different concentrations

CO_2 Concentration	Effects and Symptoms
400 ppm	Normal outdoor fresh air
400-1000 ppm (0.04-0.1%)	Typical level found in occupied spaces with good air exchange.
1000-2000 ppm (0.1-0.2%)	Over ventilation
2000-5000 ppm (0.2-0.5%)	Shortness of breath and increased heartbeat frequency
5000 ppm (0.5%)	Hygienic limit value
15,000-50,000 ppm (1.5-5%)	Headaches, sleepiness, and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present
75,000 ppm (7.5%)	Headaches, dizziness, restlessness, breathlessness, increased heart rate and blood pressure, visual distortion
100,000 ppm (10%)	Impaired hearing, nausea, vomiting, loss of Consciousness
300,000 ppm (30%)	Coma, convulsions, death

3.3.2 Carbon-monoxide

Health effects of carbon-monoxide at different concentrations for 1 hour exposure are given below: [30]

Table 3-2: Harmful effects of carbon-monoxide at different ppm

CO Concentration	Harmful effects
0-9 ppm	No health risk; normal CO levels in air.
10-29 ppm	Problems over long-term exposure; chronic CO problems such as headaches, nausea- not the most dangerous level
30-35 ppm	Flu-like symptoms begin to develop, especially among the young and the elderly
36-99 ppm	Flu-like symptoms among all; nausea, headaches, fatigue or drowsiness, vomiting.
100 ppm+	Severe symptoms; confusion, intense headaches; ultimately brain damage, coma, and/or death, especially at 300 to 400 ppm+

Carbon-monoxide is also dangerous because it inhibits the blood's ability to carry oxygen to vital organs such as the heart and brain. Inhaled *CO* combines with the oxygen carrying hemoglobin of the blood and forms carboxyhemoglobin (*COHb*) which is unusable for transporting oxygen [31]. Below is the Percentage of carboxyhemoglobin along with carbon-monoxide concentration.

Table 3-3: Percentage of carboxyhemoglobin along with carbonmonoxide concentration

CO in atmosphere (ppm)	COHb in Blood (%)
10	2
70	10
120	20
220	30
350-520	40-50
800-1220	60-70

Note: **From Carbon-monoxide (CO)** Michigan Department of Licensing and Regulatory Affairs Michigan Occupational Safety & Health Administration Consultation Education & Training Division

Symptoms associated with a Given Concentration of COHb are given below: [32]

- **10% COHb** - No symptoms. Heavy smokers can have as much as 9% COHb.
- **15% COHb** - Mild headache.
- **25% COHb** - Nausea and serious headache. Fairly quick recovery after treatment with oxygen and/or fresh air.
- **30% COHb** - Symptoms intensify. Potential for long term effects especially in the case of infants, children, the elderly, victims of heart disease and pregnant women.
- **45% COHb** - Unconsciousness
- **50+% COHb** – Death

3.3.3 Methane

The adverse effects of methane are as follows:

- Toxic by inhalation and skin exposure
- Chemicals classification: extremely flammable
- Inhalation causes agitation, slurred speech, nausea, vomiting, facial flushing and headache. In severe cases breathing and heart complications, coma and death may occur.
- Methane in its gas form is an asphyxiant, which in high concentrations may displace the oxygen supply you need for breathing, especially in confined spaces such as lungs. Decreased oxygen can cause suffocation and loss of consciousness [33].

3.3.4 Hydrogen Sulfide

The first sign of exposure to hydrogen sulfide is usually a rotten egg smell. However, the rotten egg smell usually occurs when the chemical is at a low level. At higher, more harmful levels, there is no odor. Breathing very high levels of hydrogen sulfide can be fatal. The symptoms depend upon the concentration of the gas. At the lowest concentrations, the effects are chiefly on the eyes; that is, conjunctivitis, swollen eyelids, itchiness, smarting, pain, photophobia, and blurring of vision. At higher concentrations, respiratory tract symptoms are more pronounced. Rhinitis, pharyngitis, laryngitis, and bronchitis may occur. Pulmonary edema may result. At very high concentrations, unconsciousness, convulsions, and cessation of respiration rapidly develop [34].

Table 3-4: Effects of hydrogen sulfide at different concentrations

Concentration (ppm)	Symptoms/Effects
0.00011-0.00033	Typical background concentrations
0.01-1.5	Odor threshold (when rotten egg smell is first noticeable to some). Odor becomes more offensive at 3-5 ppm. Above 30 ppm, odor described as sweet or sickeningly sweet.
2-5	Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. Airway problems (bronchial constriction) in some asthma patients.
20	Possible fatigue, loss of appetite, headache, irritability, poor memory, dizziness.
50-100	Slight conjunctivitis ("gas eye") and respiratory tract irritation after 1 hour. May cause digestive upset and loss of appetite.
100	Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours.
100-150	Loss of smell (olfactory fatigue or paralysis).
200-300	Marked conjunctivitis and respiratory tract irritation after 1 hour. Pulmonary edema may occur from prolonged exposure.
500-700	Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes.
700-1000	Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes.

Note: From Health hazards https://www.osha.gov/SLTC/hydrogensulfide/hazards.html

3.4 Summary

To summarize this chapter, it has enumerated all the natural and human sources of the four highly dangerous gases inside a building and their effects on human beings.

CHAPTER 4

ACHIEVED GOALS

4.1 Setting the Scene

Here, we'll examine how the Air Pollution Monitoring System came into being. First, a Wi-Fi administration and monitoring system must be designed and built, and then sensors must be calibrated within specified parameters.

4.2 Research Methodology

The project may be broken down into the following parts.

Developing electrical sensors for very low-level gas detection. The ranges at which various sensors may pick up each of the four gases are mentioned in the following table. Detection Range of Gas Sensors Table 4-1

Gas	Sensor	Detection range
Smoke sensor	MQ-2	300—10000ppm
LPG, butane	MQ-6	20-10000ppm
Carbon-monoxide	MQ-9	10-1000ppm
Ammonia	MQ-135	10-1000ppm

Before the concentration of the gases becomes dangerous, it is crucial that they be identified. The following table displays the critical concentration of each gas.

Gas	TLV-TWA	TLV-STEL
Smoke sensor	5000ppm	15,000ppm
Carbon monoxide	25ppm	100ppm
LPG, butane	1000ppm	5000ppm
Ammonia	-	10ppm

This enables the early identification of potentially dangerous gas levels.in the absence of any detectable gases.

- The green lights begin to glow.
- Disabling the flashing red light.

When petrol is found, if at all

- Disabling the green lights.
- The red indicator light turns on.

1. Getting gadgets to talk to one other through Wi-Fi. Users will be prompted to take necessary safety measures when the app or website receives real-time updates.
2.
3. Control and monitoring system development.
4. Establishing a Wi-Fi link between monitored devices and the system monitoring them. From anywhere in the world, the user may use an app to turn on safety measures like exhaust fans. If the user prefers to take matters into their own hands, they may use their mobile device to send a predetermined text message to their residence, allowing them to check on the status of their appliances and turn them on or off as needed. In the event of an emergency, the safety measures will activate automatically, without any intervention from the user (by cell phone or otherwise).
5. Wi-Fi compatibility in both the electrical components listed above and the system used to administer and monitor such devices.

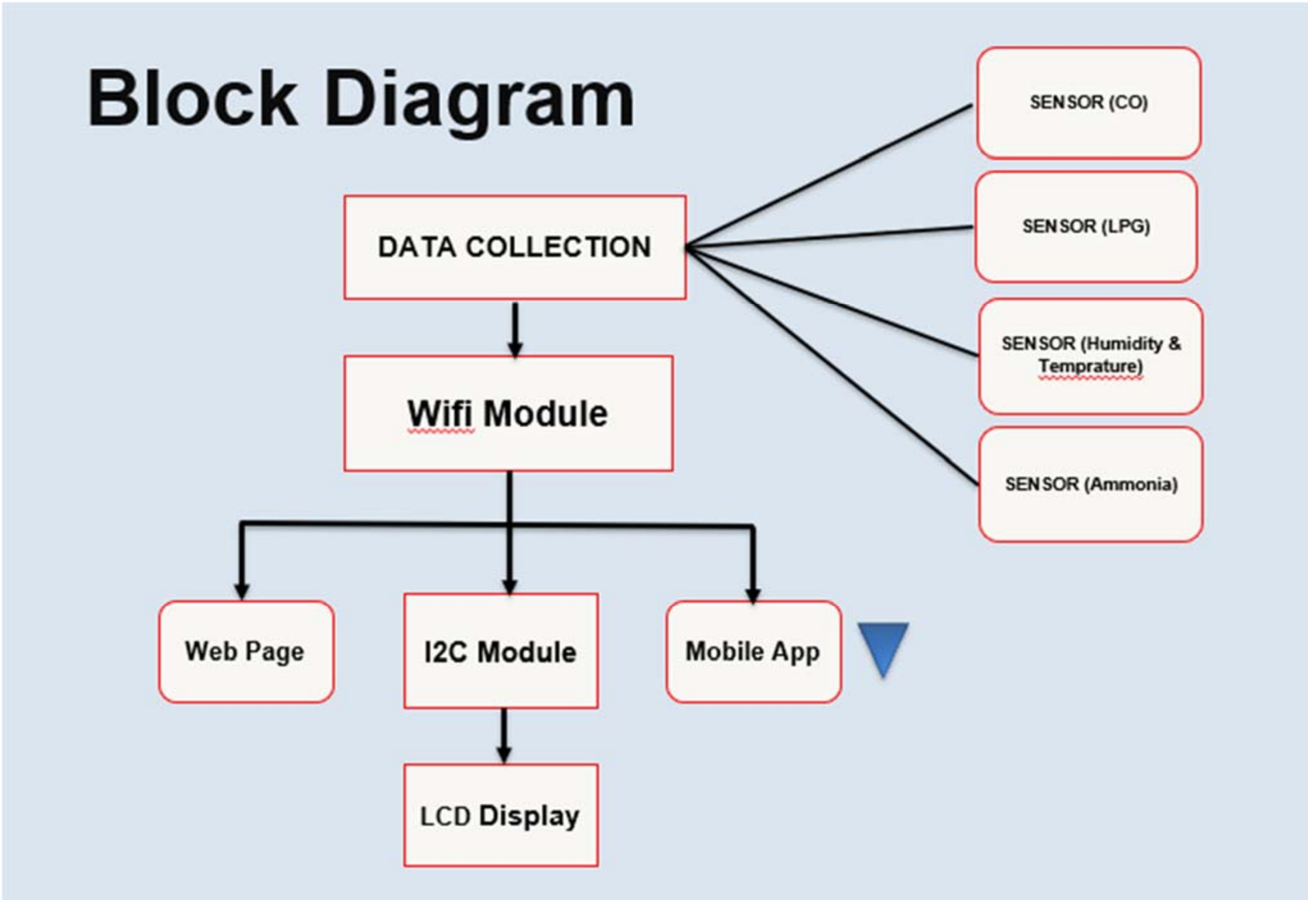

Figure 4-a **Model schematic of AIR POLLUTION MONITORING SYSTEM**

4.3 Analyzing Circuits

4.3.1 The Powering Circuit of the Electronic

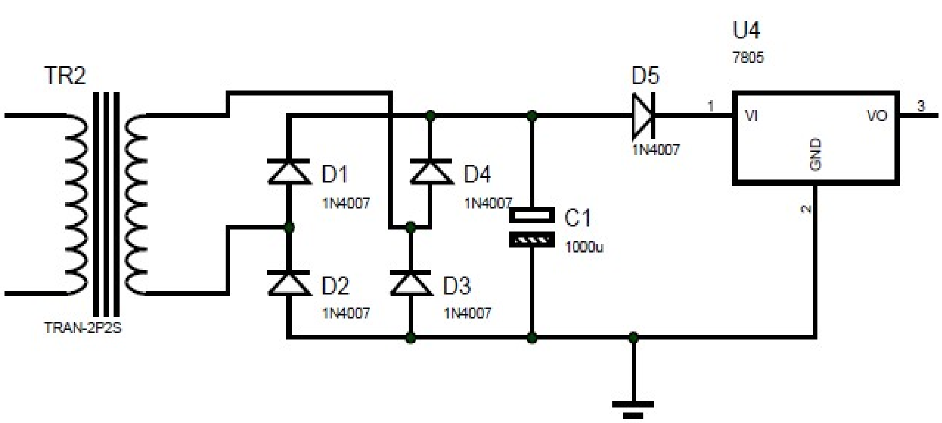

Figure 4-b ***Distribution of Air Pollution Detection Network Power.***

This circuit converts 220 volts of AC electricity into 5 volts of DC. The internal transformer steps down the voltage from 220 to 12 volts AC. The first component is a bridge rectifier circuit, which inverts 12V AC to DC. The capacitor smooths out the DC output voltage. The LM 7805 takes this input and utilises its output to provide a stable 5V supply. By connecting a diode in series with the LM7805 IC, reverse voltage is blocked.

4.4 Adding a WI-FI Module to a Network for Detecting Air Pollution

Wi-Fi modules are often included into air quality monitoring systems to facilitate remote data transmission and real-time tracking. Wi-Fi modules link up with extant wireless networks to transmit data to a centralised server or the cloud for storage and analysis.
Including a Wi-Fi adapter in your air quality monitoring setup lets you do the following:

1. A Wi-Fi module provides constant data collection and transmission, making it possible to monitor levels of air pollution in real time.

2. Increase accuracy and reliability with the help of a Wi-Fi module, which ensures secure and reliable data transfer without the risk of data corruption.

3. Increased data accessibility via web-based dashboards and mobile apps is made possible by Wi-Fi connectivity.

4. Reduce wasted time and boost output by automating routine tasks like data collection and transfer.

5. There is potential for improved real-time monitoring and analysis of air quality with the addition of a Wi-Fi module to an air pollution monitoring system.

4.5 Functionality of a Network for Detecting Air Pollution

An efficient air pollution monitoring system consists of two primary parts,

User-feedback gas detectors

Instrumental Management and Command

4.5.1 Detection of Gas and Notification of Users

The user will be notified after the gas has been identified by the Air Pollution Monitoring System.The Air Pollution Monitoring System solves the issue of the user being away from home during a gas detection by notifying them through a smartphone app and an internet interface. Each sensor is wired directly to a distinct Wi-Fi Module pin, and an interrupt pulse triggers the Wi-Fi Module's action. Then, the message is transmitted via the WI-FI module to the user's app or website.

4.5.2 Equipment for Keeping TabsKeeping a Closer Eye on

When the user manually activates a device, a notice is delivered to their app. A Wi-Fi module attached to the board will transmit information from the Wi-Fi Module's pins to the user's app. The required tracking devices are first linked to the surveillance network. When the power goes out, a pulse is generated that triggers the Wi-Fi Module, and each appliance is wired to its own unique set of pins. The Wi-Fi Module will send a signal to the Wi-Fi module if a specific pin is ever unplugged. The Wi-Fi Module will save the user's phone number, which the WI-FI module will then use to contact the user through the app.

4.6 Summary

Finally, this chapter describes the last stages of the Air Pollution Monitoring System's design and development.

CHAPTER 5

COMPONENTS

5.1 Context

The different components of Air Pollution Monitoring systems for commercial and private use are introduced and discussed in this section.

5.2 Parts and Their Descriptions

5.2.1 WI-FI Module

A micro-controller is a small, capable computer that can be designed to carry out a set of instructions and interact with other parts of a device. A Wi-Fi Module's input/output lines and memory enable it to interact with and command other

.

Figure 5-a **ESP32 WIFI MODULE**

5.2.2 Control Voltage using an LM7805

With adequate cooling, the L7805CV +5V positive voltage regulators may provide a regulated current of more than 1A. These devices were originally designed to maintain a constant voltage, however they may be combined with other parts to provide variable voltage power sources.

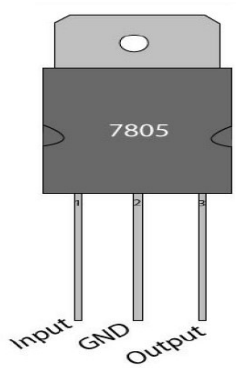

Figure 5-b ***Voltage Regulator***

These features of the LM-7805 IC are described in greater detail in the data sheet.

- Input Voltage: 10V to Start
- a constant 5V at the output
- The Vdo cutoff voltage is 2V.
- Only One Possible Results
- Three anchors
- Input Current: 500mA Max
- Container for TO-220 Voltage Regulators
- Temperatures between -150 and +150 degrees C are usable.
- Sunday, December 19, 2011 Shock Value of Human Contact: 0
- Total Number of Bases: 7805
- Type Item Quantity: 7805
- A 35V input is the maximum allowed.
- Reduced Input Voltage of 7V
- The Highest Safe Temperature is 150°C.
- the minimum operating temperature is zero degrees Celsius.

- Current Output Max: 1.5A
- The Output Voltage is 5V.
- Up to 5V Maximum Output
- to-220 container
- One kind of container is the tube.
- The Optimal Working Voltage Is 20V
- The minimum required voltage is 8V.
- Connector With a Through-Hole
- 5.0 volts
- Fixed-Voltage Positive Regulator

5.2.3 Step-Down Transformer, 220V to 12V

Using a step down transformer, the circuit's 220V AC power supply will be reduced to 12V AC.

Figure 5-c ***Transformer***

5.2.4 Relay

The fundamental purpose of a relay is to enable a circuit to be operated by a low-power signal. It's also used when one signal has to manage a large number of separate circuits. To connect and disconnect household equipment operating on 220 volts.Circuitry

5.2.4.1 For Internal Relay

Relay Schematic Located Within the Body

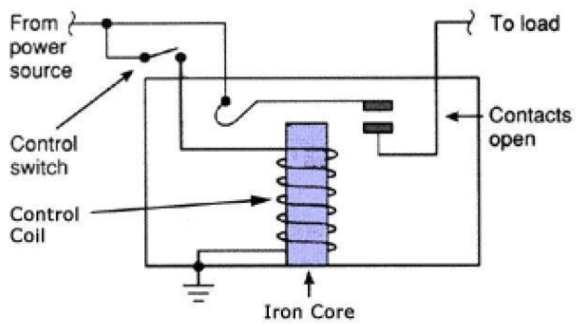

Figure 5-d ***Inside relay***

Figs5-d depict a diagram of a relay's inner workings. Around a core of iron is wound a control coil. Through a series of contacts and a selector switch, electricity is transmitted to the electromagnet.

When power is supplied through the electromagnet's control coil, the magnetic field is amplified. Therefore, the load loses power as the upper contact arm is gradually drawn towards the lower fixed arm, closing the contacts. The contacts would travel in the opposite way, generating an open circuit, if the relay were de-energized while the contacts were closed.

When the current is removed from the coils, the spring causes the movable armature to return to its initial position. It will be roughly equivalent to 50% of the magnetic pull. There are two main generators responsible for this energy. Both the spring and gravity have a role. Relays are only useful in two situations. There are uses for both high and low voltage. A greater emphasis will be placed on minimising circuit noise for low voltage uses. Their primary use is to prevent arcing in high-voltage settings. [37]

5.2.5 LCD Display LM016L Model

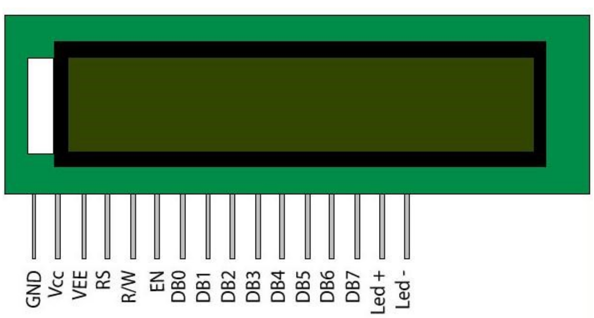

Figure 5-e ***LCD Display***

LCD display [39] pinout and description of operation displayed in the table below.

Table 5-2 depicts the LM 016L pinout.

Pin no.	Function	Name
1	Ground (0V)	Ground
2	Supply voltage 5V (4.7-5.3) V	VCC
3	Contrast adjustment through a variable register	VEE
4	Selects command register when low and data register when high	Register select
5	Low to write to the register. High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	enable
7	Data pin	DB0
8	Data pin	DB1
9	Data pin	DB2
10	Data pin	DB3
11	Data pin	DB4
12	Data pin	DB5
13	Data pin	DB6
14	Data pin	DB7
15	Backlight V_{CC}(5V)	Led +
16	Backlight Ground (0V)	LED -

5.2.5.1 Gas Detection Equipment

The sensors used are listed in the table down below.

GAS SENSOR	**FEATURES**
MQ-2 Smoke Sensor	Good sensitivity to Long life and low cost Simple drive circuit[42]
MQ-9 Carbon-monoxide sensor	High sensitivity to carbon-monoxide Stable and long life[41]
MQ-6 LPG	High sensitivity to CH4, Natural gas. Small sensitivity to alcohol, smoke. Fast response Stable and long life Simple drive circuit[40]
MQ- 135 Ammonia	High selectivity to Ammonia Compact size Low dependency on humidity Long life and low cost Low power consumption[43]

5.3 A Quick Summary

The Wi-Fi Module, voltage regulator, Relay, LCD, and sensors are all discussed in length in this chapter.

CHAPTER 6

WI-FI Adapter

6.1 An Overview of Wi-Fi Adapters

A Wi-Fi module is a piece of hardware that allows for Wi-Fi-based wireless connection. Its microprocessor, Wi-Fi transceiver, and other parts make it possible for it to exchange data with other Wi-Fi-enabled gadgets in a network. Home automation, healthcare, transportation, and Internet of Things (IoT) devices are just a few examples of the many uses for Wi-Fi modules. High data transmission rates, minimal power consumption, and seamless compatibility with existing Wi-Fi networks are just a few of the benefits they provide.

6.1.1 Wi-Fi modules: benefits and drawbacks

Benefits

- Wi-Fi modules are perfect for applications that call for constant data transmission because of their high throughput.
- Wi-Fi modules are optimised to use as little power as possible, making them a good fit for portable devices that run on batteries.
- Wi-Fi modules are widely used in IoT gadgets due to their simplicity of integration into preexisting Wi-Fi networks.
- Wi-Fi modules have a great transmission range, making them ideal for use in situations where data must be sent over a significant distance.

Drawbacks:

- Although Wi-Fi modules have a respectable data transmission range, they can't compete with other wireless communication technologies.
- Because of the proximity of other wireless devices using the same frequency band, Wi-Fi modules are sometimes affected by interference.
- Data integrity is at risk when using Wi-Fi modules due to potential security flaws such as unauthorised access and data breaches.
- Wi-Fi modules' higher price tag compared to other wireless networking technologies may prevent their widespread use in particular scenarios.

6.1.2 Uses for Wi-Fi Adapters

The following is an example of the use of a Wi-Fi module:

6.1.2.1 Wi-Fi modules have many applications in several fields, including home automation, healthcare, transportation, and more.

- To facilitate wireless connection and remote control through a smartphone app, Wi-Fi modules are often employed in smart home equipment including smart thermostats, smart locks, and smart lighting systems.
- In the medical field, Wi-Fi modules are included into equipment like blood glucose meters, pulse oximeters, and electrocardiogram (ECG) monitors to allow for wireless data transmission to healthcare professionals or mobile applications.
- Cars, buses, and trains all employ Wi-Fi modules to connect passengers to the internet and facilitate wireless communication between onboard equipment.
- Wi-Fi modules are integrated into industrial control systems to provide wireless data transfer between sensors, controllers, and other devices for real-time monitoring and management of production processes, a key component of industrial automation.
- Precision agriculture relies on Wi-Fi modules to facilitate data exchange between sensors, drones, and other pieces of hardware in order to monitor crop health and optimize production.
- Wi-Fi modules are widely used in educational institutions, including schools and libraries, to provide wireless networking among various electronic learning tools, including laptops, tablets, and interactive whiteboards.
- These are just a handful of the many industries that have found uses for Wi-Fi modules. Wi-Fi modules are widely used for wireless communication and data transmission because of their adaptability and versatility.

6.2 Synopsis

In conclusion, this chapter covers the fundamentals of the WI-FI module and some practical uses for it.

CHAPTER 7

Future research and potential uses

7.1 Purpose of This Part

The potential for further development of air pollution monitoring systems is explored, as are its current and potential uses in a wide range of industries and disciplines, including agriculture, biomedicine, cosmetics, the environment, food, manufacturing, the military, pharmaceuticals, regulatory agencies, and a number of other areas of scientific study.

7.2 To Finish

The FYP air quality monitoring system was developed to take into consideration the current emphasis on airtight building envelopes. A standalone unit is best placed in a home's primary living area. Larger, multi-bedroom houses often need more than one system. The garage, the basement, the servants' quarters, the kitchen, the attic, and the geyser will each have their own set of appliances. All of the peripherals may, but need not, be wirelessly linked to the hub device that houses the WI-FI Module.

Industrialization:

- It might be used to further numerous sectors by
- Various Detectors for Gases
- Computers with a wide range of CPUs
- Extensive Coding
- Storage Capable of Receiving and Sending Data

The hub module may be easily installed and managed from a command centre. Industrial gas sensors may be fine-tuned to detect and respond to varying gas concentrations and toxicity levels. Wi-Fi Modules may be wirelessly linked to one other and managed and monitored from a central location thanks to sophisticated programming. Separate memory modules allow for massive amounts of contacts to be saved and organised. This activity is widespread and not limited to only hotels.

7.3 Applications

Some of the many sectors that have benefited from electronic s are agriculture, biomedicine, cosmetics, the environment, the automotive industry, food and beverage production and packaging, pharmaceuticals, analytical chemistry, manufacturing, the military, government regulation, and the pharmaceutical sector. Electronic- monitoring of all stages of industrial production processes has allowed for increased quality control, leading to improved product quality, homogeneity, and consistency.

7.3.1 Subsectors of the Economy

Some chemical species in the air we breathe are crucial to human survival, while other chemical species may be harmful. Sensors that detect gases are often used in the regulation of air quality. Smart systems have numerous possible uses, and the industrial sector is only one of them.

The smart is becoming more important as it enables for hitherto unimaginable levels of environmental monitoring. Since the beginning of the Industrial Revolution, gas concentrations in the atmosphere have been steadily increasing, and they have now reached levels not seen in the last three million years.

Since it is our duty to safeguard businesses, personnel, and physical assets, a dependable detection module is a necessity. Atmospheric risks are prevalent in a variety of industrial applications.[45].

Toxic chemicals and flammable gases are often used in modern manufacturing. On occasion, gas leaks put the local population in risk. The world is constantly reminded of this issue by incidents of suffocation, explosion, and death.

The industrial sector is the third largest contributor to global warming emissions. In 2010, its emissions accounted for 20% of all fossil fuel emissions. Manufacturing, building, mining, and agriculture are all included in the broader category known as "the industrial sector." There are five major sub-industries within the manufacturing sector: paper, food, petroleum refining, chemicals, and metals/minerals. These are the regions that make the most use of fossil fuels like coal, oil, and gas. reduced carbon dioxide emissions. To generate the necessary heat and steam for the whole manufacturing process, direct burning of fossil fuels is used. Cement manufacturers, for instance, use fossil fuels to generate the 1450 degrees Celsius needed to transform limestone into cement.

The carbon content of iron may be reduced by smelting and refining to produce steel. Carbon dioxide is produced as a byproduct of oxygen reacting with iron. For every tonne of steel produced, almost 1.9 tonnes of carbon dioxide are discharged into the air [46].

Petroleum is refined into petrochemicals like polymers, solvents, and lubricants. Carbon dioxide is emitted through the breakdown of these chemicals over time. This might happen via evaporation, dissolution, or wear.

Smart is crucial in many technological contexts, including but not limited to the generation of electricity, the analysis of these four dangerous gases, and the monitoring of toxic chemicals present in the environment as a result of industrial emissions. Possible applications include regulating the ratio of fuel to air in internal combustion engines and gas boilers. Because thermal power plants also produce energy by combustion, this same principle can be applied to them as well [47].

7.3.2 Rating for Indoor Air Quality

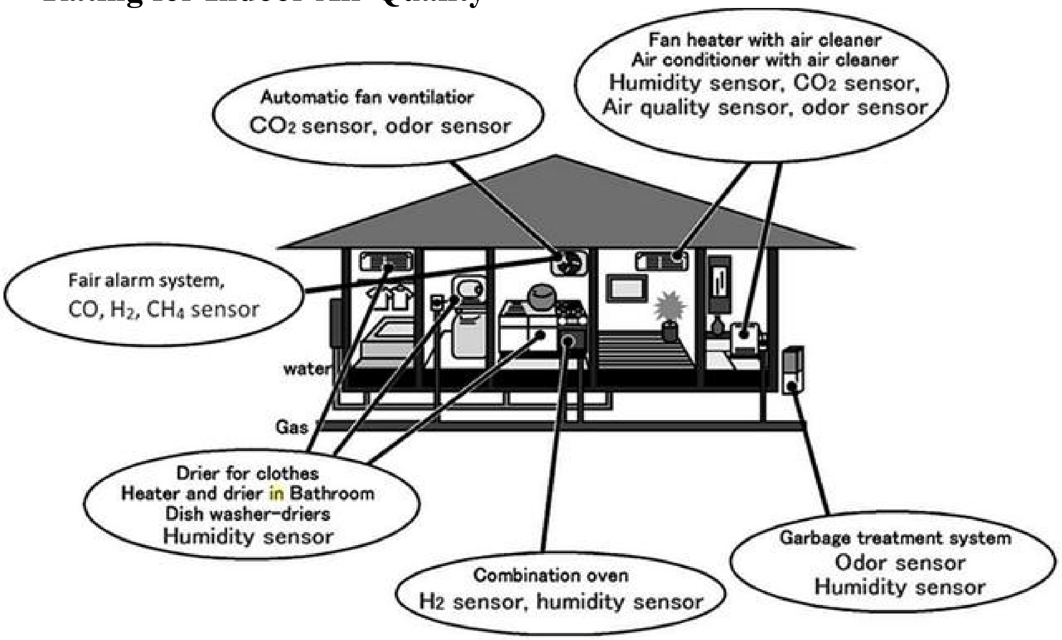

Figure 7-a ***shows the variety of gas types that may be found in homes and the corresponding sensors that are needed to detect them.***

7.3.3 Garage Parking Lots

People are looking for ways to cut their electricity consumption as the cost of electricity continues to rise. If a gas detecting module is installed in accordance with Australian Standards, ventilation fans in a parking garage may be switched off during off-peak hours. The ventilation system's energy consumption and upkeep costs are reduced as a result.

Locals benefit from less exposure to harmful automobile emissions, while the tunnel's owners get financial rewards [49]. Smart is now being used for traffic management in cities, air quality monitoring in tunnels and parking garages, ventilation regulation and the detection of petrol vapours.

7.3.4 Food

How long it stays tasty and fresh.The rate at which fruit loses its flavour, firmness, and colour as it ages is directly proportional to its degree of ripeness. Some methods of assessing fruit quality, such as the starch conversion index and the flesh firmness or pressure test, are harmful to the fruit being tested. Thus, we require a technique that is gentle on the fruit but still accurately predicts how long it will keep and increases the fruit's market value. Shalleret al. [49] evaluated an electronic 's potential for usage in the food identification process.

The pleasant scent of ripe fruit is frequently employed as a stand-in for other indicators of progress, such as personal growth. Air quality measuring instruments are used to separate coffee beans into their respective brands and individual beans within a batch [50, 51, 52]. Several benefits of milk and other dairy products contribute to the maximisation of both business profits and customer satisfaction.

Dairy products often include off-flavor chemicals that are produced by chemical reactions involving natural and synthetic microbial enzymes.

Bacterial growth, lipid breakdown and oxidation, and proteolysis all have a role in the ripening process, which in turn affects the quality, flavour, and taste of the cheese. E- is becoming more popular in this scenario.

The examination of air pollution monitoring systems was more valuable because it determined self-life and other important information, whereas an NIR spectrum (Near Infrared Spectroscopy) looks at the whole process rather than just the chemical changes that occur during storage [53].7.3.4.3 Cuts of Meat.

Meat processing companies often use air quality monitoring system data to ensure their products are both safe and fresh. Comparisons were made between the findings of the microbiological, sensory, and headspace GC tests and those of the Air Pollution monitoring system [54]. Because it can tell the difference between grilled and fresh birds so quickly, the e- is superior to other methods. Therefore, the Air Pollution monitoring system [55] may be able to detect the earliest stages of spoilage in artificially-packed chicken meat.

The Air Pollution monitoring system plays a crucial role in determining whether or not fish is fresh because its results allow for the differentiation between the odours of spoiled and fresh fish, and because it may also reveal when food has begun to rot or is no longer fit for consumption[56]. For the purpose of quality control, this module is helpful in the quick assessment of smoked salmon's freshness [57].

7.3.4.1 Cold-Storage Oysters

Using an air pollution monitoring system and a trained sensory panel evolution system, Xiaopei Hu and Parameswara Kumar Mallikarjunan(2008) analysed the effects of storing live oysters at 4 and 7oC for 14 days. The Air Pollution monitoring system correctly identifies cya 320 93% of the time, whereas the alternative technique only succeeds 22% of the time. E- has shown promise as a quality assessment tool by mapping many attributes of oysters using a combination of sensory panel assessments and data from The Air Pollution monitoring system. There was a noticeable difference in scent between oysters kept at two different temperatures for different durations of time [58].

7.3.4.2 Dried Milk and Processed Cheeses.

Using processed cheeses and evaporated milk as examples, Laurent Pillonel et al. (2001) conducted a study and found that data transmission between two e s is straightforward and easy. Researchers established a reference point using air and evaporated milk measurements, but found that e- values were more indicative of the storage stability and other important market properties of refined vegetable oils [59].

Ampuero et al. (2003) surveyed honey producers to verify its true botanical origin. The data from the samples that were lumped together and designated as typical unifloral honey was used to inform a number of models. Studies looked at many types of unifloral honey, such as those produced by acacia, chestnuts, dandelions, lime trees, fir trees, and rape. Static headspace (SHS), solid phase micro-extraction (SPME), and inside needle dynamic extraction (INDEX) were the three methods used to collect samples. When it came to classifying the data, SPME sampling provided the highest level of accuracy. The efficiency, dependability, and robustness of this approach made it ideal for the task at hand. Wheat Mycotoxins: Several Emerging Uses in the 21st Century [61]

With the goal of determining how well mycotoxin contamination levels in durum wheat may be identified[62], G. In 2005, Tognon et al. created the first technique of sensory analysis (using a "electronic "). Because of its potential influence on human health and safety, online assessment of durum wheat (Triticum durum) quality presents a major problem for the milling sector. It's great to have this research available. [63].

7.3.5 Drugs

In modern medicine, a correct diagnosis always comes before any sort of treatment. The chemical analysis of human biological samples such breath, blood, urine, perspiration, and skin is often used to identify pathological conditions. The study of fluid composition is central to the "metabolic profile concept" suggested by Jellumet al. [65]. Although the diagnostic potential of pathogen identification by research of secondary microbial metabolites was discovered and thought to be theoretically plausible as early as the 1960s [66], it wasn't until recently that scientists realised how many different VOCs pathogenic microbial species produce. Diagnostic times are lengthened because chemical analyzers for volatile organic compounds (VOCs) like GC and GC/MS are costly, need specialised personnel for analysis, and take a lengthy time. Diseased and healthy human tissues emit vastly distinct aromas, which are used in the diagnostic procedure. Studies with highly-trained dogs, whose sense of smell is one million times higher than that of humans, have provided support for the concept of human aetiology [67–69].

Experiments on the use of an electronic   to detect the volatile organic compounds (VOCs) released by various pathogenic bacteria in vitro and invivo have been presented by a number of medical researchers [70]. Three separate strains of the bacteria that causes ear, , and throat infections were identified with a 99.69% accuracy rate utilising in-situ diagnostic analysis using the Cyra 320 e- .

By evaluating the volatiles in the headspace of complicated potage cultures of Staphylococcus aureus, Klebsiella spp., Helicobacter pylori (the most frequent ulcer-causing pathogen), and Enterococcus faecalis, Pavlouet al. [72] were able to accurately differentiate between highly harmful gastro esophageal bacteria. Two anaerobic bacteria and two faecal pathogens have been successfully detected using the Air Pollution monitoring system in recent research [73,74]. Moenset al. isolated and characterised ten microorganisms with clinical significance (Pseudomonas aeruginosa, Escherichia coli, Klebsiella pneumoniae, Enterobacter aerogenes, Proteus vulgaris, Staphylococcus aureus, Streptococcus pneumoniae, Enterococcus faecalis, Candida albicans, Aspergillus fumigatus).

Di Nataleet al. [76] conducted a large-scale investigation of UTIs. The findings of the Air Pollution monitoring system have been proposed as a diagnostic tool for patients with renal problems by Pavlouet al. [73]. Aathithanet al. [77] found that 21% of 534 clinical urine specimens had clear signs of bacteriuria. E- has the potential to outperform standard approaches while reducing expenses significantly. Bacteria that cause ocular (eye) and ENT (ear, , and throat) infections were categorised by Boilotet al. [78] with a sensitivity and specificity of

There is a 97.3% and 97.6% success rate when utilising a commercially available electronic .

Patients with bacteremia and septicemia may benefit from a novel method of bacterial detection in blood cultures, as proposed by Lykoset al. [79]: sensorial analysis. Fend et al. [80] investigated blood samples to monitor and quantify dialysis dose in individuals with chronic renal failure on dialysis. Young and elderly persons with moderate to severe asthma may benefit from the findings of the Air Pollution monitoring system [81].

The etiological agent of TB, Mycobacterium tuberculosis, was studied by Pavlouet al. [82], who found that it was a global public health problem, especially in impoverished nations. One of the most controversial uses of electronic technology is in the early detection stage for identifying cancer, namely lung cancer. One possible use for this electronic is finding cancer cells [65]. It has been used to detect cerebrospinal fluid [86,87], identify bacterial pathogens [91,92], screen for the presence of many different diseases in their early stages, and diag diabetes [85]. Other applications include monitoring microbial metabolites released from superficial wounds and burns [83], upper-respiratory infections in the field of rhino logy [84], and diabetes [85].

E- s are becoming more popular since, in comparison to other medical diagnostic tools, they are both inexpensive and versatile. Many areas of medicine can benefit from this technology, including diagnostics (breath analysis, disease detection), point-of-care monitoring, medication monitoring, artificial organs and prostheses, and ground-breaking drug development. This aids in the identification of the chemical constituents of decay-derived food toxins [55].

7.3.6 Farming

7.3.6.1 The Evolution of Plants for Agriculture.

Information gathered on plants, soil, and climate are crucial in modern agricultural management. In many regions of the world, the smell of grain determines whether or not it is suitable for human eating. Sniffing grain, however, might expose you to potentially poisonous or pathogenic mould spores, such as those produced by Aspergillus species. Using information from the Air Pollution monitoring system, Campagnoliet al. [98] were able to identify processed animal proteins in feedstuffs and accurately distinguish the blank sample from all other samples.

Specialists in horticulture have verified the results of the Air Pollution Monitoring System [99] in order to expedite the selection of new commercial plant varieties. It was established that this e was useful, and it may help speed up the selection process by identifying cultivars more quickly.

The methane-producing bacteria that thrive in decaying organic materials [100] love the rice paddies, which are effectively man-made wetlands.

7.3.7 Automobiles

When the air-to-fuel ratio in a car's engine was 14.7:1, the oxygen sensor played a key role. A rich combination contains more gas than air. Air pollution is mostly generated by high mixtures of unburned petrol. More air implies more oxygen, plain and simple. This concoction is quite watery. Nitrogen oxide emissions are increased by running a motor with a lean mixture [106].

An oxygen sensor is necessary since the quantity of oxygen the engine can take in varies with factors like altitude, air temperature, engine temperature, barometric pressure, engine load, etc.

Gas sensors are being installed in an increasing number of automobiles, allowing the climate control to make adjustments automatically. After a night out, it may be used to determine how much alcohol is still in someone's system. Breath alcohol content may be used as a surrogate for blood alcohol content (BAC) you breathe out (exhale).

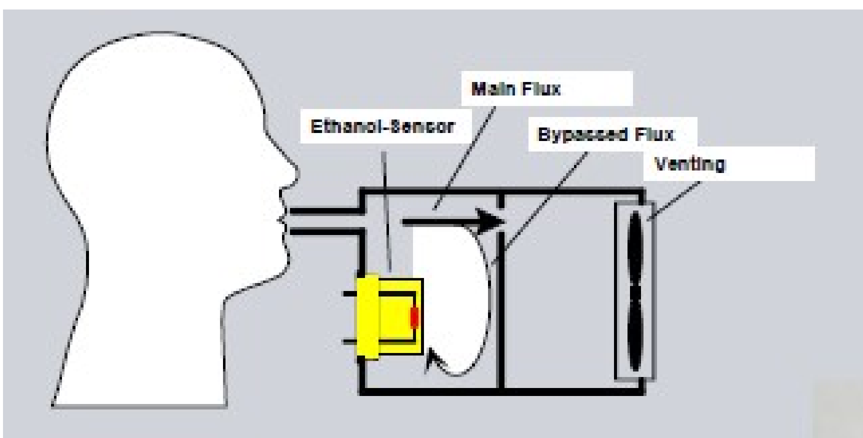

Figure 7-b ***Alcohol breath test***

Blood alcohol levels between 0.02% and 0.03% may provide a calm state of mind, whereas 0.05 and 0.10 may impair decision making. You may use this test to see whether you're fit to drive after imbibing [107,108].

7.3.8 Mines for Coal

Sixty percent of today's coal seams are located too deep for open cast mining, hence underground work is also actively used in this sector. One of the biggest problems is the presence of methane (CH_4) gas, which occurs naturally in Mine gas. As a result of geochemistry, mine gas is produced when organic matter is carbonised into coal. [109].

Blasting may release dangerous gases including carbon monoxide (CO) and hydrogen sulphide (H_2S). CH_4 concentration is proportional to the quality and thickness of coal seams. [110].

The preservation of the environment requires the use of instruments like the e- , which can identify, measure, and aid in the regulation of dangerous substances in the air. No miner should go into an area with poor ventilation (such a blind heading) unless the air there has been tested and shown to be free of dangerous gases [111].

7.3.9 Ecology and the Role of Monitoring

The word "environmental monitoring" is intentionally vague, since it refers to a wide variety of endeavours. Noise in the audio and communications frequency ranges may have an adverse effect on the environment, much as the dumping of trash in the water, land, or air.

7.3.9.1 Water

When businesses in the agricultural and industrial sectors fail to properly manage their waste, the resulting leaks into the groundwater supplies or runoff into nearby rivers threaten water quality. The e- might be used to take samples from many environments, including wastewater and boreholes. Studies suggest that information gathered from the Air Pollution monitoring system might be utilised to keep an eye on water quality.

The MOSES II e- was used by Baby et al. [112] to analyse leather industry wastes and pesticide residues that are routinely dumped into waterways. Dewettinck et al. [113] monitored volatile compounds in the effluents of a residential wastewater treatment plant for 12 weeks using a The Air Pollution monitoring system made up of 12 metal-oxide sensors. The use of evaporative technology to treat effluents from wastewater treatment plants was investigated by Van Hege et al. [114]. The evaporation process was able to effectively remove all detectable levels of inorganic and organic pollutants.

The findings of the Air Pollution monitoring system were used to the examination of wastewater samples by Di Francesco et al. [115], who used conductingpolymer sensors and fuzzy-logic-based pattern recognition algorithms. Three wastewater treatment facilities were monitored for 8 months using an electronic equipped with 12 polypyrrole conducting-polymer sensors (Fenner and Stuetz [116], Stuetz et al. [117], and Stuetz et al. [118]). According to the findings of the study, it is possible.

to monitor the biochemical processes of wastewater treatment using data collected from an air quality monitoring system.

One method for identifying blue-green algae in drinkable water was developed by Gardner et al. [119] and Shin et al. [120]. All of the potentially harmful cyanobacteria that had previously been missed by the air quality monitoring system were successfully identified using a multi-layer perceptron (MLP) neural network. The results of the air pollution monitoring system demonstrate the feasibility of using a neural network to evaluate the quality of drinking water.

7.3.9.2 Land

Toxic and radioactive waste has contaminated lands all over the globe. Problems may also be caused by landfills. Some chemicals injected into the boreholes might make electronic s more sensitive.

7.3.9.3 In the Air

Air quality has been the primary target of The Air Pollution monitoring system research projects in environmental monitoring [121, 122]. The The Air Pollution monitoring system can monitor odorous emissions at their near source or remote locations, such as paper mills, animal production sites, power-plant stacks, vehicle exhaust pipes, compost facilities, wastewater treatment plants, animal rendering plants, paint shops, printing houses, dry cleaning facilities, or sugar factories. In most cases irritating atmospheric emissions do not menace public health, and reduce the quality of life [115]. The e- offers the promise of being able to make accurate and repeatable measurements of odor profiles at sites of complaint.

7.3.9.4 Aerospace

The multidisciplinary approach required for monitoring conditions in the environments of space vehicles and in aircraft or spacecraft operations includes the development of sensor elements, integration of those elements into Smart Sensor hardware, and testing of the resulting sensor systems in application environments [124].

The Air Pollution monitoring system facilitates better environmental awareness and the identification of possible fire dangers in aeroplanes and spacecraft. Monitoring jet engine emissions requires the same capability to detect chemical species (CO, CO2, O2, NOx, and H2/HxCy, among others). Other uses for planes include fuel leak detection and environmental monitoring [124,125,126].

7.4 In Conclusion: The Big

In conclusion, in the last 20 years, there has been a meteoric rise in the number of cutting-edge healthcare and biological applications built atop The Air Pollution monitoring system. In this article, we'll have a look at how the Smart The Air Pollution monitoring system may be used in several scenarios.

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