**ARDUINO-BASED AIR POLLUTION MONITOR**

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**A PROJECT REPORT SUBMITTED TO THE FACULTY OF INFORMATON, SCIENCE AND TECHNOLOGY, COMPUTING SCIENCES DEPARTMENT IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR A BACHELOR’S OF SCIENCE DEGREE IN SOFTWARE ENGINEERING.**

**MAY 2019.**

# DECLARATION

I declare that this work has not been previously submitted for the award of a degree to this or any other University. It contains material not previously published or written, except where due reference is made in this project proposal itself.

DORCAS CHERONO

IN16/20256/15

Signature: ………………………………… Date: ………………………………..

SUPERVISOR`S APPROVAL;

This project report has been submitted for examination with my approval as the university‘s supervisor.

MR KENGERE KIBWAGE.

Lecturer

Faculty of Information, Science and Technology.

Signature: …………………………………. Date: …………………………………

# 

# DEDICATION

I dedicate this project to my family members for their full support and encouragement .

I also dedicate this project to my supervisor Mr.Kengere Kibwage for his support and guidance throughout entire developmenr of the proposal.

# ACKNOWLEDGMENT

I take this opportunity to thank the Almighty God for His guidance and His providence.

I also acknowledge my parents for providing for me especially financially to cater for all the costs incurred. I also acknowledge my supervisor, Mr Kengere Kibwahe for guiding me every step of the way and for showing me that I could do better than I always thought I would. I finally acknowledge my family and friends for the love and support in my pursuing of this project.

# 

# ABSTRACT

Air pollution is a menace in the world right now and there is dire need to work around how to control it and its effects. Measuring the extent to which the air being released into the atmosphere from industries and factories is polluted is especially a step in the right direction in working to curb overall air pollution With the current increasing rates of climatic change globally due to various modes of air pollution, there are changes in weather patterns and modification of the four seasons, the rate of ice sheets melting at the poles at increasingly alarming rates and in turn leading to submergence of coastlines. Also, there has been a considerable increase in incidences of respiratory, cardiovascular, skin, eye conditions among others in humans and animals due to this pollution. This system measures the levels of pollution in air released from factories and then it informs NEMA (The National Environment Management Authority) through Short Messaging Service (SMS). Incremental methodology will be used since later in the project, more functionalities will be added to it, for example that of directing the fumes from industrial processes through a purifying loop and only allowing them to be released into the atmosphere when the gases are confirmed as free from pollution. Data analysis for this system has been done using tools such as Data Flow Diagrams (DFD), flow charts and Input Process Output (IPO) diagrams. The system is Arduino-based and it uses an MQ135 sensor to measure the extent of pollution.

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# List of Abbreviations

|  |  |
| --- | --- |
| SMS | Short Messaging Service |
| NEMA | National Environmental Management Authority |
| UNEP | United Nations Environmental Program |
| TfGM | Transportation for Greater Manchester |
| DEFRA | Department for the Environment, food and Rural Affairs |
| GPRS | General Packet Radio Service |
| GPS | Global Position Services. |
| GSM | Global system for Mobile Communication |
| CO | Carbon Monoxide |
| NO2 | Nitrogen (II) Oxide |
| RH | Relative Humidity |
| IoT | Internet of Things |
| DFD | Data Flow Diagrams |
| IPO diagram | Input Process Output diagram |
| HDD | Hard Disk Drive |

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# CHAPTER ONE: INTRODUCTION

# 1.1 Background Information

Air pollution is defined as the presence of harmful substances in the air. It has been in the last few centuries and still remains a global menace due to its adverse effects. Holding onto the fact that the only planet which can support life is the Earth, due to its atmosphere that contains Oxygen which supports life, it is detrimental to see that it is the same (atmosphere) air that we are polluting.

Air pollution is caused by emission of gases and fumes from factories and heavy industries, combustion of fossil fuels, and natural causes such as volcanic eruptions which release greenhouse gases and aerosols that accumulate into massive clouds in the atmosphere in a process known as outgassing .Sulfur dioxide released during volcanic eruptions increases reflection of radiation from the sun leading to extreme cooling of the Earth’s lower atmosphere .Sulfur dioxide also mixes with water droplets to form acid rain which is detrimental to living organisms and property for example it causes rusting of metal. (*George, 2014).*

Effects of air pollution are adverse on animals, humans and plants. It causes diseases. Inhalation of the polluted air leads to ailments of the lungs, eyes, skin and cardiovascular system. *Pope III et al( 2006),* in their studyshow a relation of inhaled polluted air into the lungs to ailments of the blood, heart, brain, vasculature, and systemic inflammation*. Kampa et al( 2008),* in their study explain how air pollutants promote oxidative stress and induction of inflammatory responses due to their acting as pro-oxidants of lipids and proteins. Generations and generations are still affected by air pollution that happened almost a century ago- a good example of the this case being the effects still experienced by people around Hiroshima and Nagasaki where to this date children are. *Listwa( 2012*), in his study of the effects of the bombings in the cities mentioned above states that although most or probably most of the survivors have died, their children who were exposed to radiation before birth *(in utero)* were reported to have had small size heads and mental disability cases were rampant among them.

In Kenya, according to a United Nations report of 2016 titled “Actions on Air Quality”, at least 14,300 Kenyans die every year from health conditions which can be traced back to indoor air pollution with pneumonia cited as one of the biggest killers associated with air pollution. Another study led by Mary Thynell, an urban researcher at Sweden’s Gothenburg University in 2015 displays that there is a 10 times higher concentration of cancer-causing elements than the recommended threshold within the city( *Vidal, 2016. A).* A third study also around Nairobi likened the occurrence of Dementia and Alzheimer’s to the proximity of a busy road, due to air pollution*, (Chacha, 2017). R[aaschou,](https://lup.lub.lu.se/search/publication?q=author%3D%22Raaschou-Nielsen%2C+Ole%22+or+(documentType+any+%22bookEditor+conferenceEditor%22+and+editor%3D%22Raaschou-Nielsen%2C+Ole%22)" \t "_parent) et al. ([2013](https://lup.lub.lu.se/search/publication?q=publishingYear+exact+2013" \t "_parent)),* in their study did a survey that proved that particulate matter pollution contributes to lung cancer incidences in Europe.

Prevention is better than cure-and so measuring of the extent of pollution of air to be released especially as a result of human activities is a step in the right direction in curbing and reducing air pollution and its adverse effects.

# 1.2 Problem Statement

Air pollution, defined as the presence of harmful compounds and elements in the air is a global menace that has been affecting our world from the days of our forefathers. It is caused mainly by day-to-day human activities though nature also sometimes, through means such as volcanic eruptions that produce a lot of harmful gases, contributes to air pollution. It causes chronic diseases and even premature deaths of animals and human beings especially due to inhalation and effects on the skin, and also on plants. Air pollution also causes degradation of the protective Ozone layer of the atmosphere which in turn allows harmful ultra-violet B sun rays that cause skin cancer on humans and animals such as dogs, and severe damage to plants .Air pollution also causes global warming whose indicators are melting of ice sheets on the poles and consequent rise in sea and ocean levels that causes submergence of coasts. There are no adequate mechanisms put in place to measure air pollution. This system provides a mechanism to measure air pollution and relay the data through SMS (Short Messaging Service), then it saves the data in a database, for generation of reports. Currently, existing systems use Bluetooth and network-based means like, which require connectivity to such technologies to have been put in place. Also, internet connectivity is an extra cost, and it is not as readily accessible to in remote areas.

# 1.3 Objectives

# 1.3.1 General Objective

The main objective of this project was to develop an application that with the help of sensors measures the extent of pollution in the air by industries.

# 1.3.2 Specific Objectives

(i) To perform a field study in order to gather information on existing air pollution monitors and their drawbacks.

(ii) To gather and analyze requirements for the proposed system.

(iii).To design and develop an Arduino-based air quality monitor system that measures the extent of pollution of air released especially by industries.

(iv). To test and validate the system for efficiency and conformance to the requirements.

# 1.4 Scope and Boundary

This system limits itself to factories and industries. It monitors air pollution in air released as a result of industrial processes, and relays the values through SMS to NEMA officials.

# 1.5 Justification

The earth is the only planet whose atmosphere can support life due to presence of Oxygen. With the increasing menace of air pollution globally, very soon our atmosphere will be too polluted to even support life if no action is taken. Since air pollution cannot just be measured by assuming that since the fumes released are not dark-grey and dense that they are not polluted, there has been need to develop systems that can actually measure the extent of pollution of air. Later, this project will be advanced to ensure that after fumes are measured and gauged polluted, they are not released but re-directed back to the purifying chamber until they are dubbed pure, safe and not harmful to living organisms. This system assists NEMA to monitor the extent of pollution of fumes released as a by-product of industrial processes. It eliminates the need of internet and Bluetooth connectivity to relay this information, which will be done through SMS.

**CHAPTER TWO; LITERATURE REVIEW**

# 2.0 Introduction

Air pollution sensors are devices that detect and monitor the presence of air pollution in the surrounding area. They are used for both indoor and outdoor environments. These sensors can be built at home, or bought from certain manufactures. The sensors were very expensive in the past, but with technological advancements they are becoming more affordable and more widespread throughout the population. These sensors help serve many purposes and help bring attention to environmental issues beyond the scope of the human eye.

The 21st Century has seen a trend towards the development of cheaper portable air-quality sensors. These sensors all work by;

1. Using a gas sensor that is able to measure the air for pollution.
2. Relaying the information to selected parties.

# 2.1 Case Studies of Existing Air Pollution Monitoring Systems.

Sample projects that I researched on that are also measuring the extent of air pollution all over the world, which are geared towards curbing air pollution are as below;

# 2.1.1 The Smart Air Quality Monitoring For Nairobi Case Study.

Kenya’s capital, Nairobi, is highly urbanized and industrialized, which are two of the major causes of air pollution.De Souza, P. (*June 2016*), in his study of some of the measures that the United Nations Environmental Program, (UNEP) is taking to prevent and curb air pollution noted that this body put in place air pollution monitors around the city to collect and relay data to servers for observation, which is a step in the right direction in achieving a considerable decrease in air pollution levels and its hazardous effects. Air pollution monitors from a company called Alphasense were put up in 5 sites deemed as pollution hotspots. These sites included an urban background, the Alliance Girls’ High School, a site near a garbage dump site which was the Kibera Girls Soccer Academy, a site near the Thika Super Highway, which was at St. Scholastica, a site near Mbagathi way and the few industries around it- the All Saints’ Cathedral School and the last one at the LungaLunga Community center which is near a site where manufacturing of chemicals that are used in the production of teargas. These devices update their data on the Alphasense Company’s server. Advancements being worked on include; automatic update of data and how to make it available on UNEP’s site and some of the drawbacks of this system include that it is a lot of work to manage the data and that the deployment of network is expensive too.

2.1.2 A Case Study of a Real-Time Traffic Emissions Monitor In Stockport, United Kingdom**.**

Stockport Borough authorities together with the Transport for Greater Manchester (TfGM) and the Department for the Environment, Food and Rural Affairs (DEFRA) came up with a device capable of measuring air pollution using pervasive sensors and then relays this information through iGATE Intelligent Gateway device to a web server using wireless technology. These devices, called E-MOTES, can measure up to three gases together with noise, temperature and humidity.

These devices are Bluetooth enabled and among other features, they are also GPRS (General Packet Radio Service) enabled.

# 2.1.3 The EveryAware Sensor Box

# 

This is a portable device that uses several sensors to measure the extent of air pollution once every second and localizing it using GPS (Global Positioning System). This frequent updates each second are used to produce a detailed pollution map say when walking.

Using an application installed called the AirProbe, the data of all users is combined and can be viewed on *[www.airprobe.eu](http://www.airprobe.eu).*

This device has a total of ten sensors, eight used for measuring air pollutants while the remaining two are used for temperature and humidity. The sensors are as follows;

(i).The Alphasense CO-BF, CO sensor

It was the most effective tested low cost gas sensor in terms of the results obtained.

(ii).The E2V MiCS­5521, CO sensor, and MiCS­2710, NO2 sensor

This one was not effective in terms of the readings but in terms of pricing, it was favourably cheap

*(iii).E2V MiCS­5525, CO sensor with charcoal filter*

It being enhanced with charcoal increased the sensor reaction time, and enhanced selectivity of the sensor.

*(iv). Figaro 2201, gasoline and diesel sensor*

This sensor contains two sensing elements, one which senses Gasoline exhaust fumes and another that senses diesel exhaust fumes. It was designed to be used in intelligent vehicles.

*(v). The E2V MICS-2610 Ozone sensor*

It is very sensitive to the presence of Ozone and is also very effective in terms of power usage.

*(vi). The Applied sensors AS-ML, VOC (Volatile Organic Compounds) Sensor*

This one is applicable since it measures volatile organic compounds though it was aimed at indoor ventilation systems.

*(vii). The Sensirion SHT21, T (Temperature) and RH (Relative Humidity) sensors*

This high quality combination of sensors was highly recommended due to its high precision measurements and its past good working interaction with these sensors.

# 2.1.4 A Case Study of an Air Quality Application Based On IoT (Internet of Things) In BeitMisk, Lebanon.

This is an Internet of Things project that has been put in place in BeitMisk residential area in Lebanon. These sensors are used to advise on what time it is best to go jogging, or when it is best for kids to go out to play and also avail knowledge on when to add more air filters to power generators. These sensors measure parameters such as Ozone, Carbon Monoxide, Nitrogen dioxide, Sulfur dioxide and Particle Matter.

This application has a web dashboard, a chat bot and mobile application incorporated into it and thus information can be retrieved from either of these three avenues.

**2.1.5 The Campbell Scientific Air Quality and Pollution Systems.**

Their monitoring stations are composed of data loggers that measure the sensors, then processes then stores the data and finally transmits.

Their sensors measure the air for pollution by harmful gases and also by particulate matter. In addition to this, sensors in their stations also measure the soil temperature, air temperature, water temperature, relative humidity, wind speed, wind direction, delta pressure, barometric pressure and precipitation.

Data retrieval used by this company includes telephone, on-site, short-haul, radio frequency and satellite. They have an automatic computer-based application to help monitor the measurements and are willing to even help their clients display the data online.

# 2.2 Summary

This system is ensuring a decrease in the amount of harmful gases released into the atmosphere thus helping curb air pollution in whichever small ways.

It scraps off the excuse of lack of knowledge as to whether gases are polluted or not as an excuse for causing air pollution. It also avoids the need for internet connectivity to put in place such systems. It uses SMS to send the values of how polluted the air is, as opposed to existing systems which rely on Bluetooth and internet connectivity.

# CHAPTER THREE: METHODOLOGY

Research methodology is a description of how data for system development was gathered and analyzed .In this chapter, I will describe the techniques I used to gather the data and analyze it.

# 3.1 Development Methodology;

This project’s algorithm development is implemented using the incremental process model due to the fact that the proposed system is open to advancements in future.

The incremental process model can be defined as a ‘multi-waterfall’ process model as it involves coming up with a finished and working system will every increment. A working system is available in early stages of development and there is increased functionality with every incremental development.

The improvements on this particular system may include introduction of a looped purifying process which would ensure that the air is only being released after it is totally free of pollutants.

Build 1

Implementation

Testing

Design and development

Build (n-1)

Requirements

Implementation

Testing

Design and development

Implementation

Testing

Design and development

Build (n)

*Figure (a). Diagram showing how the system is modelled through the incremental methodology.*

# 3.2 Data Collection Tools

1. Observation- This method of data collection involves observing the existing systems and how they work.
2. Use of questionnaires- This method of data collection involves giving out questionnaires, some to individuals who have worked with the existing systems in order to find out what they think should be improved in how these systems work.

# 3.3 Analysis and Design Tools;

These are graphical tools used to design the system which help in easier contemplation of what the system does and how data flows in it.

**Data flow diagram;**

A data flow diagram, (dfd) is a diagram that shows the flow of data in a system .It diagrammatically shows input data, output data and stored data within the system. There are two types of data flow diagrams; a Logical one shows system processes while a physical one shows the implementation of data flow in the system. They comprise of data flow, entities, data storage and processes.

**Flowcharts**

These also use diagrams to represent flow of information and use certain shapes to represent various activities like processes and arrows to represent the flow of information in the direction of the arrow. The difference between a flowchart and a data flow diagram is that the flow chart shows the flow of control while the latter describes the flow of processes.

**Input Process Output diagram (IPO diagram)**

This is a design tool that diagrammatically shows how an input is processed to become an output and the process in-between.

# 3.4 System Implementation Tools and Techniques;

The algorithm implements the following tools;

**Hardware**

Arduino kit

1. Arduino MQ135 gas sensor, buzzer, GSM (Global System for Mobile communication) kit, breadboard, resistors.
2. Laptop core i5 and above, 2.3 GHz and above, 4 GB RAM and 500 GB HDD (Hard Disk Drive).

**Software**

1. C and C++ (which are the languages used to program the Arduino board)
2. Windows/ Mac/Linux Operating Systems to run the Arduino programming environment on.
3. Arduino 1.8.5.
4. MySQL database.

# 3.5 Testing and validation;

System testing and validation was performed to affirm that the system does conform to the specification, does what it was intended to, in the intended time frame and manner and does not do what it was not supposed to do.

**System Testing**

This form of testing involved testing the whole system for verification and validation against its objectives.

**Black Box Testing.**

This is a mode of testing in which the tester does not have any back-end knowledge of the system and due to this reason it can be done by even people with little/ no knowledge of programming.

Software validation was done to ensure that a system conforms to its specifications and is usually done after verification.

# CHAPTER FOUR: System Analysis and Design

## 4.0; INTRODUCTION

In this chapter, the analysis and the design of the system are described.

## 4.1. SYSTEM ANALYSIS

The air pollution monitor is an Arduino-based system that helps monitor the extent of pollution in gases released as a by-product of industrial processes. This is made possible through a combination of micro-controllers and sensors. The sensor that detects the extent of pollution of these gases is a MQ135 gas sensor. The MQ135 gas sensor has the ability to sense Ammonia (NH3), Nitrogen Oxides (NOX), Sulphides, alcohols, aromatic compounds, Benzene, smoke and other gases that are harmful and pollute the atmosphere and this makes it the suitable sensor to detect harmful gases released into the atmosphere as a result of industrial processes, and generally in the atmosphere. It is coated with sensor layer of Tin dioxide (SnO2) which is an inorganic compound that has a lower conductivity when exposed to clean air than when exposed to polluted air thus with high conductivity, it means the air is polluted.

The MQ135 sensor displays its data on air quality in units called PPM (Parts per Million). This air pollution monitor then sends the data over the GSM to NEMA officials, to the industry’s environmental administrative personnel and to then inputs the data in to the MySQL database .To notify the officer in charge of these industries and other parties involved in the individual industries, apart from the data relayed from the GSM, data is relayed to the MySQL database for generation of reports, a buzzer is activated for readings exceeding a certain limit, that is, those termed as displaying a value depicting ‘polluted air’. A red LED light is also turned on by readings that represent polluted air and SMS’s sent to NEMA officials at intervals with a warning that a certain company X is polluting the atmosphere, together with the value of the readings, while a green LED is activated for readings that depict clean air. Each company’s unique identifier is the mobile number from which this data is received through text, and the GPS too, provided by the GSM/GPS board used to send texts from the factory location. These readings are also inputted into Microsoft Excel, from the database for the generation of reports.

## 4.2 REQUIREMENTS SPECIFICATION;

## 4.2.1 Functional requirements;

A functional requirement is described as a function or a component of a system. The following are the functional requirements of the air pollution monitor are as described below.

1. The system monitors the extent of air pollution of gases released from the industries using an MQ135 sensor.
2. The system uploads the readings obtained to the Lora gateway and then relays values of polluted air through SMS.
3. The system lights an LED warning light when the values depicts polluted air.
4. The system activates a buzzer on sensing polluted air.
5. The system generates reports through Microsoft Excel.

## 4.2.2 Non-functional requirements;

1. Performance- the system gathers the data and relays it through SMS.
2. Efficiency- the system collects, processes, outputs and transmits the data in frequent intervals while consuming very little battery power and low storage space on the micro-controller.
3. Scalability- the system handles frequent output and notifies through SMS, the buzzer and the LED only when the air is polluted.
4. Security- the system is secure from being tampered with. The fact that data readings are relayed in specific intervals, then it means that once there is no reading at the expected time then, it has been tampered with.
5. Interoperability- The system uses the Internet of Things technology. This means that it can also be implemented on other microcontroller boards apart from Arduino, for example the Raspberry pi and the Intel Edison. The only difference is that there are various air quality sensor used for the different micro-controllers, but they achieve the approximately the same results.

## 4.3 SYSTEM DESIGN;

MQ135 gas sensor module;

This is the module that programs the MQ135 gas sensor, which is the sensor that senses the extent of pollution of the gases being released from the industry. This sensor has the ability to sense harmful gases like; Ammonia (NH3), Nitrogen Oxides (NOX), Sulfides, alcohols, aromatic compounds, Benzene, smoke and other gases that are harmful and pollute the atmosphere and it displays the measurements in PPM (Parts per Million). This module is set such that it displays all the data but only data that represents polluted is relayed through the GSM/ GPRS module. It is also programmed in such a way that when the gases are polluted, it activates the buzzer and a red LED.

Arduino Uno module;

This module programs the hardware and the sensors. It is the backbone of the system because it enables all other modules to exist. It is used to program the micro-controller to perform different tasks depending on the sensors incorporated.

### GSM/GPRS module;

This module facilitates the relay of the values obtained from the MQ135 gas sensor. However, this module relays only the data that depicts that the air is polluted. This data is relayed to the NEMA officials and the local officers in charge of the environment in the respective areas where the industries are located. The text relayed by the GSM serves as a warning that a certain industry X is polluting the environment in a certain area. Each of these Air pollution monitors relay data from different mobile phone numbers and this serves as one of the unique identifiers of which specific industry the data is being relayed from.

### Buzzer module;

This module is for the buzzer, which is activated once the values reach a certain level. This level is usually set as at a level which once the readings being relayed by the gas sensor, it is activated. This serves as a notification to the workers in the industry that the gases they are releasing into the atmosphere are polluted and that they are harmful to the environment.

### LED module;

The LED is activated at the same time as the buzzer. It serves as a warning to the industry officials and workers that the gases being released at that moment are polluted and they are causing harm to the environment. A green LED is activated for readings that do not represent polluted air and a red one is activated to depict readings of polluted gases. It goes off after a set period of time, at the same time as the buzzer.

## 4.3.1 Architectural Design;

Data sensing

Sensor node.

Data

Sensor data

Arduino Uno

Sort and Relay data

GSM/GPRS

LED light

Buzzer

*Figure (b). Data flow diagram for this air pollution monitor;*

Arduino Uno, GPS, GSM, Serial monitor, MQ135 gas sensor, buzzer, LED, double x=0.

Upload the code to the microcontroller

Display the results on serial monitor and send them to the database.

Light green LED.

STOP

*Figure (c).Flowchart*

START

*Showing the flow of data*

*In this system.*

Send the value readings through SMS to the Industrial manager and NEMA officials, light the red LED and activate the buzzer.

Is x>300?

# CHAPTER 5: IMPLEMENTATION AND TESTING

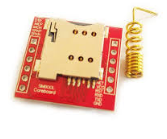
## 5.1; Implementation;

This system is developed using C programming language, which is used to program the Arduino micro-controller.

The images below are for the hardware components used to create this air pollution monitoring system;



*Figure (d). Arduino Uno*

*Figure (e ).GSM/GPRS module Figure (f). MQ135 Gas sensor.*

*Figure (g). Buzzer Figure (h). LED diode.*



*Figure (i). Jumper cables.*

## 5.2; Code snippets;

GSM/GPRS code;

if(sensorvalue>255){

digitalWrite(buzzer,HIGH);

delay(100);

digitalWrite(redLED, HIGH);

delay(100);

digitalWrite(greenLED, LOW);

delay(100);

mySerial.print("AT+CMGF=1\r");

delay(100);

mySerial.println("AT + CMGS = \"+2547xxxxxxxx\"\r"); *//text sent to the modem*

delay(100);

mySerial.println(sensorvalue);

delay(100);

mySerial.println((char)26);

delay(100);

mySerial.print("AT+CMGF=1\r");

delay(100);

mySerial.println("AT + CMGS = \"+2547xxxxxxxx\"\r"); *//text NEMA officials*

delay(100);

mySerial.println("This industry is polluting the environment. Reading=");

delay(100);

mySerial.println(sensorvalue);

delay(100);

mySerial.println((char)26);

delay(100);

mySerial.print("AT+CMGF=1\r");

delay(100);

mySerial.println("AT + CMGS = \"+2547xxxxxxxx\"\r"); *//texts the industrial manager*

delay(100);

mySerial.println("Your industrial process is emitting poisonous gases. Reading=");

delay(100);

mySerial.println(sensorvalue);

delay(100);

mySerial.println(sensorvalue);

delay(100);

mySerial.println((char)26);

delay(100);

Serial.println("pollution alert!!!!");

delay(100);

}

else{

Serial.println("No pollution");

digitalWrite(buzzer,LOW);

delay(100);

digitalWrite(greenLED, HIGH) ;

delay(100);

digitalWrite(redLED, LOW) ;

delay(100);

}

}

void server(){

unsigned long currentMillis=millis();

if (currentMillis-previousMillis>=interval){

previousMillis=currentMillis;

if(timetosend==LOW) {

timetosend=HIGH;

if(Sentdata<2){

mySerial.print("AT+CMGF=1\r"); //set to text mode

delay (200);

mySerial.print("AT + CMGS =\"+254719444791\"r"); //phone number to send to.

delay(100);

mySerial.print(reading);

delay(200);

mySerial.print((char)26);

}

Sentdata=+1;

}

else{

timetosend=LOW;

}

digitalWrite(commled, timetosend);

}

Buzzer module;



LEDs module;

if(sensorvalue>250){

digitalWrite(LED,HIGH);

mySerial.print("AT+CMGF=1\r");

delay(100);

mySerial.println("AT + CMGS = \"+254719444791\"\r");

delay(100);

mySerial.println(sensorvalue);

delay(100);

mySerial.println((char)26);

delay(100);

Serial.println("pollution alert!!!!");

}

else{

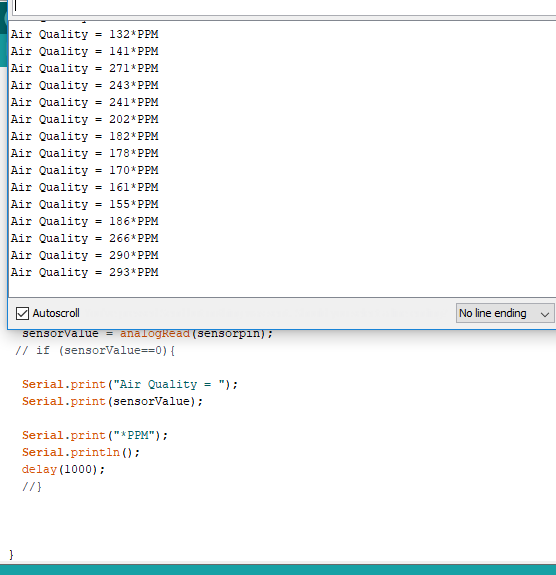
Serial.println("No pollution");

digitalWrite(LED,LOW);

}

## 5.3: Snapshots;

*Figure (j). Air quality readings when the system is exposed to a pollutant gas;*



## 5.4; Testing;

This system is first tested under normal conditions, that is, in an area where the air is not polluted. A pollutant gas is then deliberately introduced and the system is tested again.

A considerable increase in the readings when the pollutant is introduced and as the system is continuously exposed to these conditions.

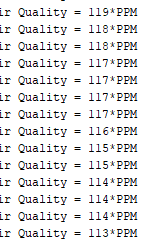
5.4.1; System Testing

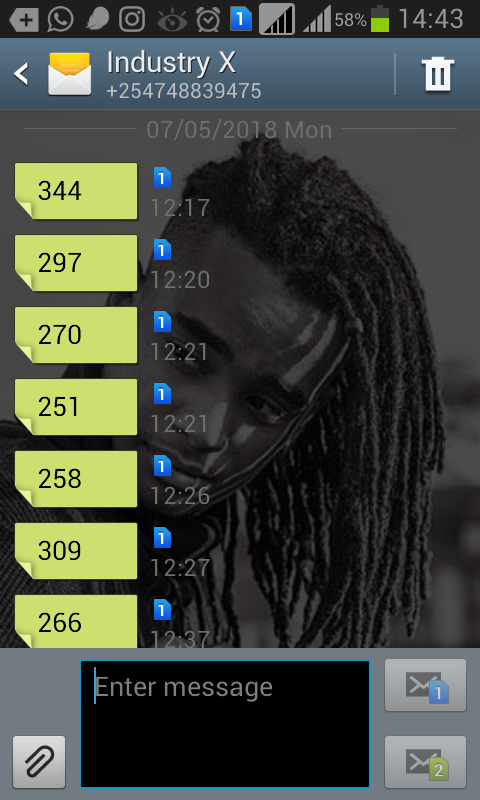
The whole system is tested against its set of objectives to see whether it fulfils them accordingly. The objectives of the system are; to measure the extent of pollution of gases released from industries, to notify NEMA officials in the case of pollution and to validate that the system fulfils the requirements.

5.4.2; Black box testing;

The system is tested without knowledge of the back end of the system. The tester does not know what the code looks like and probably has no knowledge of C programming language. They just test the system under controlled conditions where the air is not polluted and observes and records the readings.

Readings are also taken when the system is exposed to an environment where the air is polluted, and they are recorded.

*Figure (k). Air pollution readings when the air is not polluted.*



*Figure (l).* *Screenshot of texts sample texts sent to NEMA officials.*

It is observed that there is a considerable increase in the concentration of the readings, depicting that the system is working due to the differing readings when exposed to both conditions.

# CHAPTER 6: SUMMARY, CONCLUSION AND RECOMMENDATION

## 6.1 Summary;

This system monitors air pollution successfully through sensors. It does so through the MQ135 gas sensor which has a layer of tin oxide that is sensitive to polluted air. The gas sensor is sensitive to sulfur oxide, nitrogen oxide, carbon monoxide, benzene and steam among other dangerous gases to the atmosphere. This sensor displays the values obtained through the serial monitor, then relays through the GPS/ GPRS to the NEMA officials, the environmental-relations manager, and relayed to the MySQL database. This data is then displayed in Microsoft Excel for manipulation.

If the gases released are poisonous that is, polluted, a buzzer is activated and at the same time a red LED warning light is activated. An SMS is also sent to the NEMA officers in charge of that geographical area and to the industrial manager in charge of the environment, and lastly to the database. This will warn them that the company is releasing polluted gases and action needs to be taken to avoid any more effects to the atmosphere.

## 6.2 Conclusion;

This system monitors air pollution in gases released as a by-product of industries. Unlike existing air pollution monitors this system is specially designed for industries and it incorporates relay of data through SMS. It also activates warning mechanisms which are the buzzer and the LED light once air pollution is detected, unlike existing systems.

## 6.3; Recommendations;

* Air pollution monitoring should incorporate mechanisms of relaying data that do not only require internet connectivity, but also, those that include SMS and other cheaper data relay mechanisms. This will reduce the cost of implementation of air quality monitors by getting rid of the need of internet connectivity. Also, they should include warning mechanisms for when the readings depict polluted air such as buzzers and a light warning (LED light in this case).Hardware should be made more available in the country and in Kisii County. The university should try adopt a mechanism to ship these Arduino hardware gadgets on behalf of students in bulk to reduce the cost.

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# Appendices;

*Table 1: Time Schedule*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| LENGTH IN DAYS | 1 | 30 | 20 | 20 | 40 | 20 | 1 |
| IDEA GENERATION |  |  |  |  |  |  |  |
| PROPOSAL WRITING |  |  |  |  |  |  |  |
| REQUIREMENTS GATHERING AND ANALYSIS |  |  |  |  |  |  |  |
| DESIGN |  |  |  |  |  |  |  |
| CODING AND TESTING |  |  |  |  |  |  |  |
| DOCUMENTATION |  |  |  |  |  |  |  |
| FINAL PRESENTATION |  |  |  |  |  |  |  |

***Table 2: budget***

|  |  |
| --- | --- |
| ITEM | COST (Kshs) |
| Printing and binding  Stationery  Photocopying Cost  1 Flash Disk and 5 CDs  Arduino Uno board  MQ135 Gas Sensor  Buzzer  ESP8266-01 Wi-Fi Module  Resistors(1 Pack)  GSM shield  Laptop  Miscellaneous | 700  400.00  800.00  250.00  4,500.00 |
| TOTAL | 70,750.00 |