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Air Quality Monitoring with Arduino and Android

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Air pollution is one of the major threats of recent times. Air quality monitoring is very important as it has direct impact on human health and environment. It has become an essential need to control air pollution to provide a safer future for the next generation. Indeed the thought of attempting to lower the impacts of air pollution is of great stature, but before that, we must understand the pattern of the air pollution data. Data regarding air quality, toxins, dust etc would not only help us understand where the state of a country is but also help identify places in a country that are prone to health hazards. In this paper a cost efficient, portable, easily manageable Arduino based device has been presented to monitor air quality. By monitoring air quality, we mean collecting data of quantity of gases and amount of dust present in air. This device can be located at any place and the data can be transferred to an Android phone via Bluetooth within the Bluetooth's range or simply by connecting the device to a Pc/laptop. Data from different places can be later examined to make further decisions and analysis; furthermore it can also help concerned individuals to act upon it. From data comes research and humans can only act upon a situation when enough data and research is present and this is where our device will come into play.

Field of Research: Environmental Engineering

1. Introduction

Air pollution can be defined as an atmospheric condition in which various substances are present at concentrations high enough above their normal ambient levels to produce a measurable effect on people, animals, vegetation or materials (Bangladesh environment 2015). Air pollutants are dangerous to human health as well as environment too. If the concentrations of air pollutants increase, it can be fatal for this world and the living things on it. Air pollution contains quantum amounts of Carbon monoxide (CO), Sulfur dioxide (SO2), Nitrogen oxides (NOx), Ozone (O3), Hydrocarbons (HC), lead (Pb) and Suspended Particulate Matter (SPM). These are some of the pollutants that have given rise to diseases and environmental catastrophes.

Human beings and natural activities cause air pollution. Natural events that pollute the air are forest fires, volcanic eruptions, wind erosion, evaporation of organic compounds and natural radioactivity. Human activities that cause air pollution include emissions from industries and manufacturing activities, burning fossil fuels, vehicles, household and farming chemicals etc.

This is where our device comes into play. The purpose of the device is to detect certain harmful air pollutants and log the amount at which they are present. This device can provide data of how much aggravated a place is in terms of air pollutants. The device outputs numbers in a predefined range when exposed to certain

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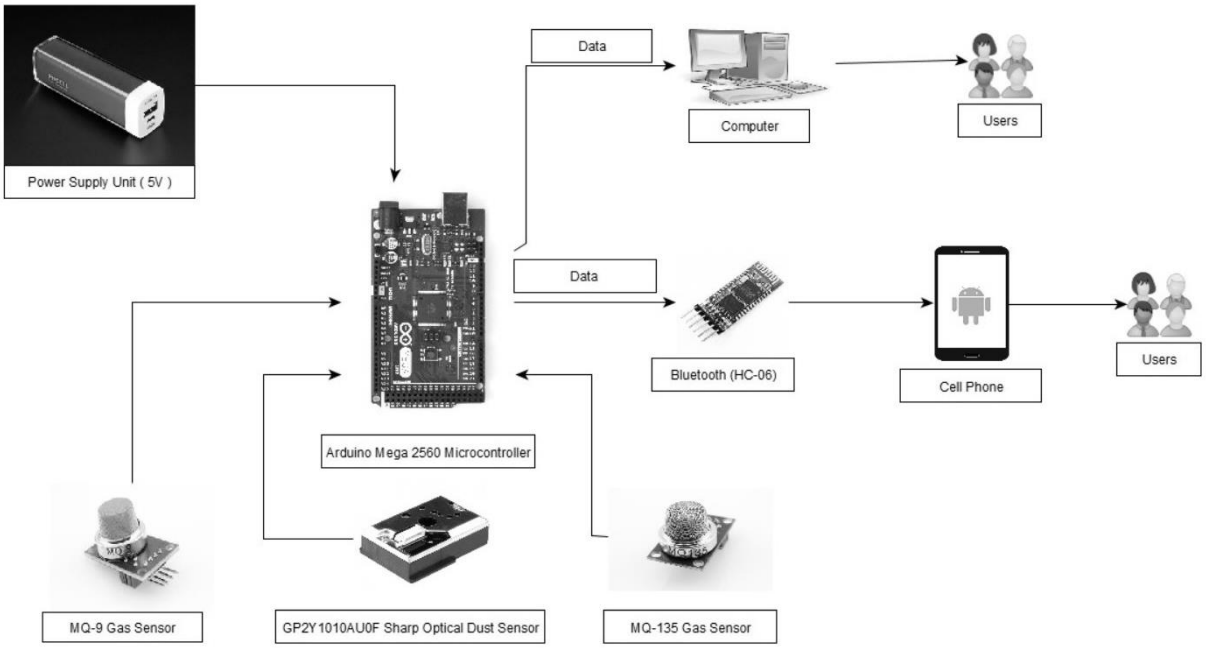
pollutants which will be discussed further. It can be used to monitor industrial air pollution, furthermore It can also be used in hospitals and sophisticated places where air pollution should be as less as possible. Examples include hospitals, Children's Nursery, baby carriages, schools etc. The data provided from the device can be used to distinguish between polluted and less polluted areas.

The hardware of the device consists of three sensors which include Sharp's optical dust sensor GP2Y1010AU0F, gas sensors MQ-9, MQ-135, HC-05 Bluetooth module and an Arduino Mega board. The device measures the pollutants in the air and generates real time data, which can either be seen in a computer or an Android device using the Bluetooth module.

The overview of the whole system is shown below in Figure 1,

Figure 1: Overview of the Proposed System



2. Literature Review

Air Pollution has been one of the major issues of the world. Regarding this issue many research work has been conducted. "Design and Implementation of Indoor Environmental Quality Monitoring System Based on ZigBee" (Liu et al., 2015) presents a wireless monitoring system which monitors environmental parameters like temperature and humidity. In another work called "Arduair: Air Quality Monitoring" (Chaudhry 2013) shows a low-cost and portable device which can be placed anywhere and the data can be plotted graphically in real time.

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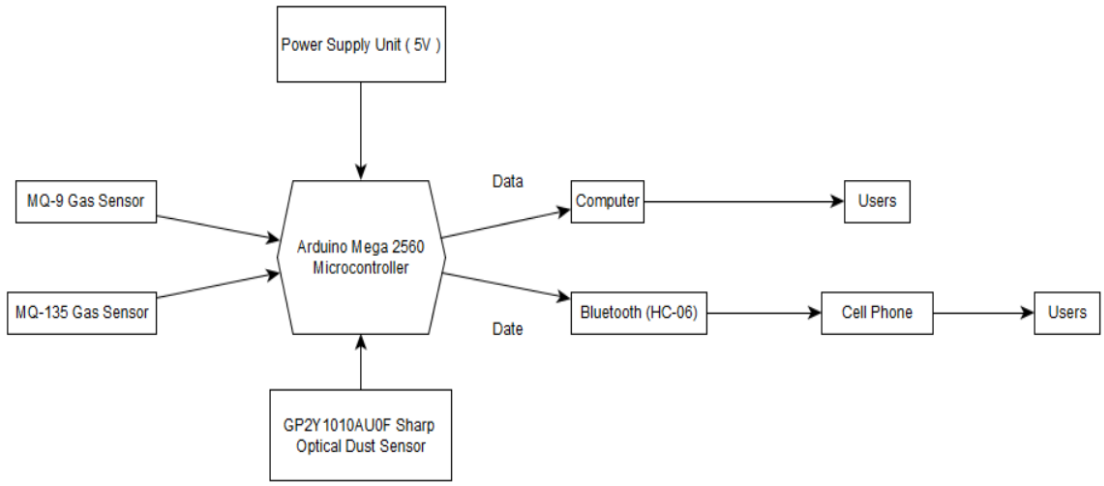
In a journal known as “Monitoring Of Green House Gases Using Wireless Sensor Networks with Arduino Board” (Vadlamudi and Bhrinda, 2015), they monitored the greenhouse gas leakage such as CO2, NO2, humidity and temperature from industries and the data collected by the co-ordinator is updated into the webpage available on web server. A similar journal called “On-line Monitoring of Green House gases Storage and Leakage Using Wireless Sensor Network” (Reddy and Natarajan, 2015) also showed an on-line green house gases monitoring system based on wireless sensor network is implemented using X-bee Digi modules and open source hardware platform Arduino.

A research paper known as “Wireless Measurement Node for Dust Sensor Integration” (Khadem et al., 2012) proposes the combination of two technologies by integration of an optical interferometer dust sensor with a conventional sensor networking platform through a data acquisition module.

3. Methodology

In total three sensors were used to monitor the air quality and they are MQ-9, MQ-135 and optical dust sensor GP2Y1010AU0F.The sensors are connected to Arduino Mega 2560 board and when the Arduino is powered on, the sensors start to generate data continuously in real time on the computer screen. The data can also be transferred to an Android phone using Bluetooth communication with the device. The user would simply have to connect to our device using their Android phone via Bluetooth and by using our Android application data transfer would become possible. The data mainly consists of air pollutant intensity values. Higher values indicate higher air pollutants and vice versa. The block diagram of the whole system is shown below in Figure 2.

Figure 2: Block Diagram of the Proposed System



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4. Discussion

4.1 Hardware Components Used in the Proposed System

4.1.1 Arduino Mega 2560 Microcontroller:

Arduino is the perfect microcontroller due to its high performance and special features. The ATmega2560 AVR (Arduino 2015) comes with an entire set of program and system development tools including macro assemblers, C compilers, in-circuit emulators, program debugger /simulators and evaluation kits. It has 54 digital input/output pins (of which 15 can be utilized as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The ATmega2560 was chosen for the proposed system design due to its low cost with full efficient and excellent interfacing capability with air quality sensors such as MQ-9, MQ-135 and GP2Y1010AU0F Sharp Optical Dust Sensor. The picture of Arduino Mega 2560 is shown in Figure 3.

Figure 3: Arduino Mega 2560 Front & Back Side

4.1.2 MQ-9 Gas Sensor:

MQ-9 gas sensor (Seeedstudio 2015) has high sensitivity to Carbon Monoxide (CO). The sensor high sensitivity to CO and ignitable gases; it has low cost and is suitable for different applications such as Industrial/Portable gas detection. The delicate material utilized as a part of MQ-9 gas sensor is tin dioxide (SnO2), which has lower conductivity in a clean air medium. At the point when the target CO is detected, the sensor's conductivity rises and increments proportionately as the degree of CO gas increases. The MQ-9 gas sensor was chosen for high performance detection range(i.e.)10-1000ppm for (CO),100-10000ppm for ignitable gas which has got its quick reaction time and is a low controlled powered device (<5V) [3]. This sensor has diverse resistance esteem in distinctive concentration. The picture of MQ-9 Gas Sensor is shown in Figure 4.

Figure 4: MQ-9 Gas Sensor Front & Back Side

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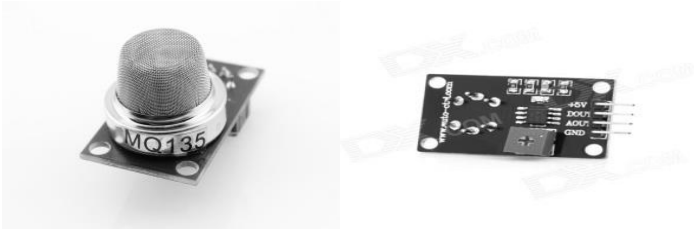
4.1.3 MQ-135 Gas Sensor:

MQ-135 gas sensor (Waveshare 2015) has high sensitivity to detect different types of gases. They are used in air quality control equipment's for buildings/offices, are suitable for detecting of NH3, NOx, alcohol, Benzene, smoke, CO2 ,etc. The delicate material used in MQ-135 gas sensor is tin dioxide (SnO2), which has lower conductivity in a clean air medium. At the point when the target gas is detected, the sensor's conductivity rises and increments proportionately as the extent of gas increase. The MQ-135 gas sensor was chosen for high performance detection range (i.e.) 10ppm-300ppm NH310ppm-1000ppm Benzene, 10ppm-300ppm Alcohol which has got its fast response time and is a low powered device (<5V) [4]. This sensor has different resistance value in different concentration. The picture of MQ-135 Gas Sensor is shown in Figure 5.

Figure 5: MQ-135 Gas Sensor Front & Back Side



4.1.4 GP2Y1010AU0F Sharp Optical Dust Sensor:

GP2Y1010AU0F Sharp Optical Dust sensor which is a minimal, ease optical dust sensor, comprising of an infra-red emanating diode and a phototransistor, was utilized as air quality sensor as a part of the system. It identifies airborne particles utilizing scattered light and is equipped for recognizing fine particles. It is normally utilized as a part of air purifiers and air screens. The sensor has very low current consumption (20mA max, 11mA typical) and can be powered with up to 7VDC. The output of the sensor is an analog voltage proportional to the measured dust density, with a sensitivity of 0.5V/0.1mg/m3 (Sparkfun 2015). The sensor was chosen because of its compact size, envisioned for integration in air purifiers or air conditioning units which is also suitable for our design. The picture of GP2Y1010AU0F Sharp Optical Dust Sensor is shown in Figure 6.

Figure 6: GP2Y1010AU0F Sharp Optical Dust Sensor

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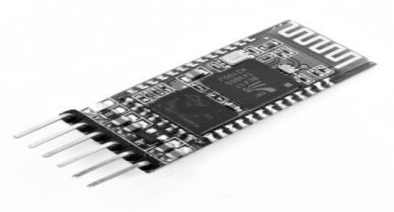
4.1.5 Bluetooth (HC-06):

Bluetooth serial module is used for converting serial port to Bluetooth. It uses the UART protocol to make it easy to send and receive data wirelessly. This module is a slave only device which means that it can connect to most phones and computers with Bluetooth but it cannot connect to other slave only devices such as keyboards and other HC-06 modules. The input voltage range is 3.3V to 6V. HC-06 Bluetooth module was adopted for wireless communication with a range of up to 30 feet. Bluetooth has been perceived as a viable mode for short range data communication due to the fact that it has moderately low power utilization and ease compared with Wi-Fi or GSM information/data transmission (Piguino-Wiki 2015). The picture of Bluetooth HC-06 is shown in Figure 7.

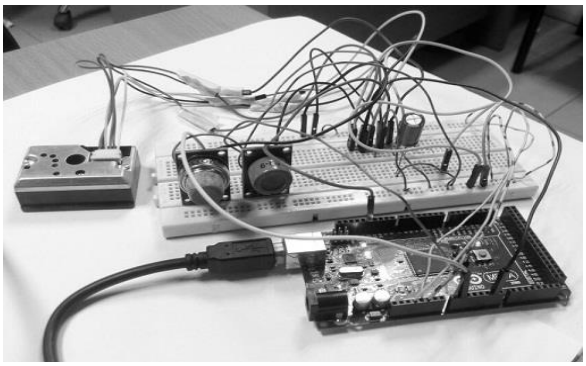
Figure 7: Bluetooth (HC-06)



4.2 Prototype of the Proposed System

When the Arduino is powered on by 5volt battery or a USB power supply, the entire system will become functional. Each sensor of the device produces their individual reading. Each sensor has been calibrated according to our needs and the users can change calibration at anytime in order to receive output values according to their specific requirements. The hardware design of the proposed system is shown in Figure 8.

Figure 8: Prototype of the Proposed System



The MQ-9 gas sensor when subjected to the carbon monoxide produces output in the form of voltages that can be calibrated according to real world scenarios. It has a variable resistor on its body which can be used to calibrate the output voltage of the device. According to our scenario higher readings in the range (1-1000) tend to indicate higher levels of carbon monoxide.

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The MQ-135 gas sensor when subjected to NH3, NOx, alcohol, Benzene, smoke, CO2 produces output in the form of voltage. We have scaled it to our requirements where the readings are between 0 to 5, where values closer to 0 indicates better air quality and higher values indicates worse air quality.

GP2Y1010AU0F Sharp Dust sensor has a similar functionality as it also produces voltage values when subjected to dust in air. It also produces values among the range (1-1000) where the values closer to 1000 indicate a more dusty condition.

The general purpose of the Bluetooth module, known as the HC-06 is to transfer data from the device to the Android phone or any Bluetooth terminal device. This makes it convenient to transfer data between two different Bluetooth enabled devices.

4.3 Android Application of the proposed system

In order to make data collection process more convenient, we opted to choose the Android mobile platform because of its popularity and productiveness. In order to collect the data from the device to phone an Android application was built using the Android SDK (Developer.Android 2015). The application will run on phones with a minimum requirement of the operating system Ice Cream Sandwich. The Application functions by making the user pair, the phone with the physical air quality measuring device via Bluetooth. After successfully establishing connection, the user is prompted to load the data to their phone. This process retrieves the data from the air measuring device to the Android phone using the Bluetooth. The data later can be saved on to the physical memory/SD Card of the phone.

4.4 Results

The air analyzer device requires 5volt input voltage to function. The voltage source can be a USB powered brick or a battery pack that can deliver the functioning voltage. The device is plugged with MQ-135, MQ-9, Optical Dust sensor and a Bluetooth module. All the individual components function distinctively and produce their own outputs. The entire device works as a perfect data logging unit that can keep log of the level of dust, carbon mono-oxide and NH3,NOx, alcohol, Benzene, smoke, CO2 in an environment. Once the device is powered on, the sensors will be turned on and will start generating data which will be sent to two mediums, the com-port and the Bluetooth module. Sending it to two different mediums is done so that the end user can witness data either in their Android phone or the computer that they are working on. The output seen from computer screen and Android phone are shown below in Figure 9 & 10.

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Figure 9: Output Seen on Computer Screen

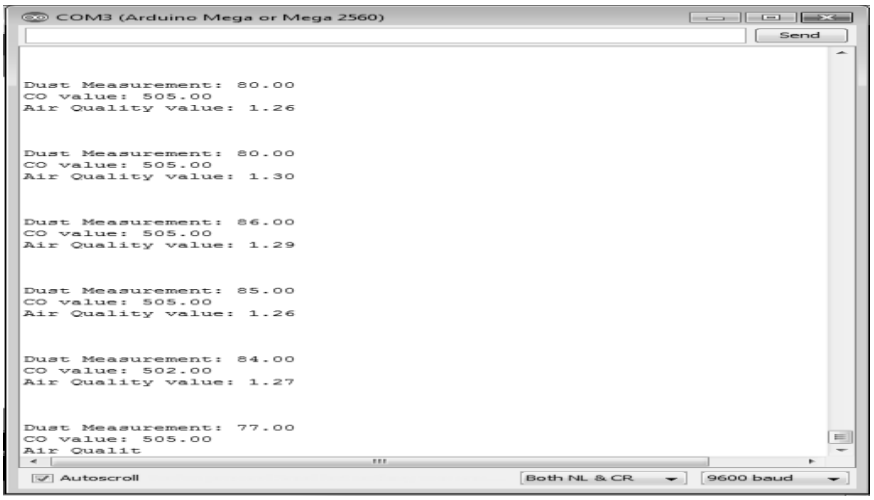
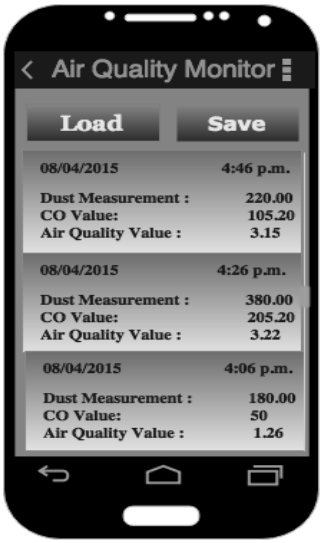


Figure 10: Output Seen on Android Application



The device can be placed anywhere and data can be taken from anywhere within the Bluetooth's range. We opted to provide further convenience to the users of the device by developing the Android application which will receive the data from the device when connected. Figure 9 shows data being sent to the serial monitor of a computer having an Arduino development environment.

This device is affordable and easy to use. There may be many air monitoring devices available in the market but they may be quite expensive. The proposed device is cheaper and more user friendly. The cost of this device has been listed below in Table 1.

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Table 1: Price list of the components used in the proposed system

Item No.	Device	Quantity	Cost ($)
1.	Arduino Mega 2560	1	6.20
2.	MQ-9 Gas Sensor	1	2.10
3.	MQ-135 Gas Sensor	1	1.94
4.	GP2Y1010AU0F Sharp Optical Dust Sensor	1	4.09
5.	Bluetooth (HC-06)	1	2.95
			Total : 17.28 USD

5. Comparison between the existing systems and the proposed system

There are some existing systems which monitor the Air Pollution, but the proposed system has many advantages over them.

It can be seen from Table 2 that the existing system might be much more sophisticated from the proposed system but in terms of price and monitoring air pollutants, the proposed system excels but at a less cost.

Our proposed device is modular. If any of the sensors malfunctions, they can be easily replaced without having to replace the entire device.

Table 2: Comparison between the existing systems and the proposed system

Device Name	**Air Pollutants measured by the device**	**Price**
Indoor Air Quality Meter - CO2, Temperature & Relative Humidity	CO_2, Temperature & Relative Humidity	$129.00
Mini CO2 Monitor	CO_2	$109.00
PYLPCMM05 - PYLE PCMM05 Carbon Monoxide Meter	Carbon Monoxide (CO)	$227.24
The proposed system	Carbon Monoxide (CO), NH3, NOx, alcohol, Benzene, smoke, CO_2, Dust	$17.28

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6. Conclusion

The proposed device can be used to monitor air quality in many aspects. It can be used in industry, hospital, streets and many other places for daily monitoring. It can be very useful for the parents as well; as they can ensure safety of their children by using the device to monitor air pollutants. It's a compact device to monitor air quality from any place. This device can be used for further research on air pollution due to its ability to transfer data logs. This will make the people more aware of the air pollution around them. Analysis of the big-data from the device will bear fruit to enhancement of the world. Decisions regarding safety can be taken once enough data is present to support the cause. This is where the device will shine.

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