AIR POLLUTION MONITORING SYSTEM BASED ON AIR POLLUTANT INDEX(API) AND GEOGRAPHIC INFORMATION SYSTEM(GIS)

by

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A thesis submitted to the Department of Computer Science and Engineering
in partial fulfillment of the requirements for the degree of
B.Sc. in Computer Science

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BRAC University
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Declaration

It is hereby declared that,

1. The thesis submitted is my own original work while completing degree at BRAC University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I have acknowledged all main sources of help.

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Approval

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Abstract

Air pollution is the most alarming fact in modern world. Air pollution monitoring system is common research field with tremendous new information which can be used to find out the main air pollutants. In this research the goal is to design an air pollution monitoring system using the Air Pollutants Index (API) data retrieved from Dhaka US Consulate and Geographic interpolation System (GIS) via Inverse Distance Weighted (IDW) interpolation methodology with ArcGIS Pro and ArcGIS 10.5 software to find out air pollutants concentration in atmosphere using some basic gas sensor and other components. In this research, i have collected data from ten to twelve different clumsy and polluted area of Dhaka City which are overly polluted by the dust, burned fuel smoke, brick kilns and dangerous particle of matter. Those area is my study area. The aim is to prepare a model which will measure the amount of pollutant elements present in our environmental air. Our main objective is to compare the Dhaka US Consulate data with our proposed sensor model data and develop an air poluution map.

Keywords: Air Pollutants; Air Quality Index(AQI); ArcGIS Pro; Air Pollution Index(API); Geographic Information System(GIS); Inverse Distance Weighted(IDW) interpolation; MQ sensors; Arduino Uno; Dhaka US Consulate

Dedication

This thesis work is dedicated to my parents, my friends and my supervisor Dr. Amitabha Chakrabarty for his outstanding support throughout my entire thesis.

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Firstly, all praise to the Great Allah for whom my thesis have been completed without any major interruption.
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Nomenclature

The next list describes several symbols & abbreviation that will be later used within the body of the document

$AQMP$ Air Quality Management Program

BRT Bus Rapid Transit

$CASE$ Clean Air and Sustainable Environment

CO Carbon Monoxide

$CO2$ Carbon Dioxide

DoE Department of Environments

ECR Environmental Conservation Rules

HC High Court

$HRPB$ Human Rights and Peace for Bangladesh

IoT Internet of Things

LPG Liquid Petroleum Gas

MCE Mixed Cellulose Esters

$NCDs$ Non-Communicable Diseases

$NH3$ Ammonia

$NIOSH$ National Institute for Occupational Safety and Health

NOx Nitrogen Dioxide

$PM10$ Particulate Matter diameter of 10 micrometer

$PM2.5$ Particulate Matter diameter of 2.5 micrometer

ppm Parts Per Million

SEI Sustainable Environmental Initiatives

$SnO2$ Stannic Oxide

STP Strategic Transport Plan

SUT Sustainable Urban Transport

TTL Transistor-Transistor Logic

WHO World Health Organization

Chapter 1

Introduction

1.1 Thoughts behind the Model

Air is the most important element of human environment. No animal can live a single moment without air. But we do not think that it is we who pollute this most vital element. Air pollution means the way in which the air is being polluted trough different types of particle. Clean air is essential for life. Air is is being polluted many ways. For example smoke pollutes air, man makes fire to cook food, to make bricks burns refuse,melts pitch for road construction and burns wood. All these things produce heavy smoke and this smoke pollutes air. The another example is that railway engines, power houses, mills and factories use coal and oil. Moreover,buses,trucks and cars use petrol and diesel oil. Again all these things create smoke and cause air pollution. Furthermore, the most serious air pollution occurs in big industrial areas where there are many mills and factories. "At a country level, weighted by population, Bangladesh emerges as the most polluted country," said the 2018 World Air Quality Report released few days before.Bangladesh has the most polluted air in the world and Dhaka is the second most polluted capital city, according to a new study. The average air quality of Dhaka and the entire Bangladesh are different. The air of Dhaka city is more polluted than any other city of Bangladesh.

According to a recent report, air pollution will cause around 7 million premature deaths globally next year and have a major economic impact. Dhaka, known as most polluted city in the world also have to suffer that effect. Millions of pollutant elements are present in the living air right now. Every single day, millions of vehicles, mills, factories, industries pollute the air in a large scale. We know serious air pollution occurs in big cities where there are many buses, trucks and cars plying in the street everyday. For that reason, sometimes men in big industries area become so sick by inhaling polluted air that they can not be cured. People are often known these factors and it's effect on human life. So they don't take any pre-cautions.

Accordingly to a resent report Dhaka ranked 17th in world polluted city list, where Gurgaon, a suburb of the Indian capital New Delhi ranked top of that list. On that village women and girls are being more affected than men by air pollution. Bangladesh, one of the most densely-populated countries in the world, has been struggling with air pollution for long period of time. Brick kilns were the major source of air pollution followed by construction work. Government has taken vari-

ous steps to reduce emission of harmful smoke from brick kilns, including promoting cement blocks and eco-bricks for construction work. But the process is not working accurately all around Dhaka city. New brick fields are rising near the city area. Savar, Ashulia, Tongi, Fotulla, Gabtoli Ghat are the most polluted area near Dhaka city due to brick kilns smoke. Air pollution is present both inside homes and outside and is responsible for the premature death of seven million people each year, including 600,000 children, according to the special rapporteurs UN environmental annual report [4]. Due to metro rail, fly-over construction works, the roads of Dhaka city is being polluted with some heavy particulate matter like Sulfur, Iron, Zinc, Lead and Phosphorous. Those elements are mixing with air due to drilling and digging process of pier pilling. Everyday people have to suffer dust and dirt problem on those area. They are suffering with some respiratory diseases.

Air pollution is a pressing issue in our country as Bangladesh ranks 169th (out of 178 countries) at the Environmental Performance Index for Air Quality (APT, 2016). The main sources of air pollution include emission from faulty vehicles, especially diesel run vehicles, brick kilns and dust from roads and construction sites and toxic fumes from industries. The main pollutants from gasoline powered internal combustion engines are Carbon Monoxide (CO), Hydrocarbons (HC), Nitrogen Oxides (NOx), Sulfur Dioxide (SO2), particulates of Lead compound and un-burned Carbon particles. Emissions from diesel engines are smoke, CO, un-burned carbon, NOx and SO2.

According to the Bangladesh Department of Environment (DoE), the density of airborne particulate matter (PM) reaches 463 micro grams per cubic meter (micro gram) in the city during the dry season (December-March) which is the highest level in all around the world. World Health Organization (WHO) air quality guidelines (2005) recommend a maximum acceptable PM level of 20micro gram, cities with 70micro gram are considered highly polluted. A study conducted by the scientists of Bangladesh Atomic Energy Commission revealed that about 50 tons of Leads are emitted into Dhaka city's air annually and the emission reaches its highest level in dry season. In that time those particle with mixes with air and go directly to human body through respiratory system.

Poor ambient air quality is causing damage to human health, agricultural production and materials. It is high time to create awareness and motivation about air pollution across the country. In different times air pollution issues have been considered, and often guided by the multinational agencies like the World Bank, Asian Development Bank, United Nations Environment Program, have taken measures or have made plans to reduce and control air pollution. But due to some difficulties those process did not work perfectly. Recently, our Government has started some awareness among people to reduce air pollution.

The objectives of the AQMP included reducing vehicular emissions in the metropolitan areas, setting standards, enforcing pilot programs towards cleaner technologies, as well as implementing air quality monitoring and evaluation. This led to the revision of the ambient air quality standards of Bangladesh in July 2005. Other notable projects aimed at air quality management include certain components of the Clean

and Sustainable Environment (CASE) Project supported by the World Bank, the Bangladesh Air Pollution Management Project, and the Implementation of Malé Declaration. The overall objectives of these projects focused to abate air pollution and introduce energy efficient technology for brick sector and vehicles [5].

All these issue is responsible for me to develop an air polluted area map and find out which elements are solely responsible for air pollution. So that people can take precaution from harmful air pollutant elements.

1.2 Aims and Objectives of the research

Most of the people of Bangladesh do not know about the harmful effect of air pollution. They suffer with multiple respiratory diseases during a long period of time. Many people had died due to proper treatment. The aim is to prepare a model which will measure the amount of pollutant elements present in our environmental air. Our main objective is to compare the Dhaka US Consulate data with our proposed sensor model data. Understanding the different attributes is also needed in order to get more accuracy in result. Finally we will make such a map which can be monitored by Android devices using internet. This project will analyze and identify high concentrated air pollutants area in Dhaka city. Finally, prepare a map using ArcGIS software.

1.3 What is air pollution model ?

Air pollution is a serious environmental health hazard affecting the population as well as environmental element of Bangladesh. The following table 1.1 shows the air pollution related data which indicates the pollution level of Dhaka city in recent days.

The amount of polluted air is increasing day by day all around Dhaka city. The air pollution model is to define the pollutant elements concentration in living air.

1.4 Why should we need this model ?

Every morning we have to cover our face with a mask or with a handkerchief to go our working places. It's really uncomfortable during the summer seasons. If we forget to take that pre-cautions, our nose,eyes,face will cover with dust and dirt. Our mental condition become irritating on those moment. Seven million people suffer premature deaths due to household and outdoor air pollution every year around the globe, according to the World Health Organization. More than 4,300 cities in 108 countries are now included in WHO's ambient air quality database, making this the world's most comprehensive database on ambient air pollution.

More than 90 percent of air pollution-related deaths occur in low- and middle-income countries, mainly in Asia and Africa, followed by low- and middle-income countries of the Eastern Mediterranean region, Europe and the Americas, the WHO said.

Area wise collected data		
Area	Date	Avg. AQI
Uttara(Diabari)	1 Apr 2019	126ppm
Uttara(House Building)	2 Apr 2019	164ppm
Khilkhet	3 Apr 2019	207ppm
Badda Notun Bazar	4 Apr 2019	238ppm
Badda	5 Apr 2019	231ppm
Rampura	6 Apr 2019	279ppm
Mogbazar	7 Apr 2019	226ppm
Motijheel	8 Apr 2019	253ppm
Shahbag	9 Apr 2019	235ppm
Mirpur	10 Apr 2019	274ppm
Gabtoli	11 Apr 2019	241ppm

Table 1.1: Air Pollution Index of Different areas

"Air pollution threatens us all, but the poorest and most marginalized people bear the brunt of the burden," Tedros Adhanom Ghebreyesus", director-general of WHO, said in a statement.Among the cities of over 14 million residents, Dhaka has been ranked third in terms of the presence of fine particulate matter with a diameter between 2.5 and 10 micrometres (PM10) in air. The data focuses on particulate matters with a diameter between 2.5 and 10 micrometres (PM10 or less) and particles with a diameter of less than 2.5 micrometres (PM2.5). The distribution of the seven million deaths is largely uneven with the vast majority of the pollution-induced deaths being taking place on the poorer countries. Non-communicable diseases are the leading causes of deaths globally and air pollution contributes significantly to NCDs such as cardiovascular diseases, respiratory diseases and lung cancer. Since 2016, more than 1,000 additional cities have been added to the database, which shows that more countries are measuring and taking action to reduce air pollution than ever before.

According to the WHO, Dhaka is ranked as one of the top mega cities in the South East Asian region where residents are exposed to pollutant air particulates. Nine out of 10 people breathe air containing high levels of pollutants, the WHO said in a statement issued in Geneva yesterday. While the acceptable levels of PM10 in every cubic metre is 60, in Dhaka's air it is 147. The WHO is the custodial agency for the Sustainable Development Goal Indicator to substantially reduce the number of deaths and illnesses from air pollution by 2030. If we don't take urgent action on air pollution, we will never come close to achieving sustainable development. We have to make awareness among the common people to known about the harmful air pollutants and which areas should avoid to live.

1.5 Why not other possible solution should be used ?

Bangladesh is a developing country, not a developed one. Each year we need billions dollar budgets to fulfill our basic human needs. Government takes effective steps to make awareness about air pollution and it's harmful effects. But this awareness is not spreading massively to all people of Bangladesh.

Now a days, most of the people uses a smart phone. We are spending a long time by Facebook browsing and chatting. If we develop such an app or live map of densely polluted area through an android program, we can easily spared the messages throughout a huge number of people to create awareness. To do so, this is the only possible method to crate awareness among people about air quality and various kind of air pollutants.

1.6 Problem Statement

There are few issues to the problems associated with air pollution. Firstly, the government ignorance about public safety. Secondly, implementation of rules against air polluted organization. Thirdly, massive amount of brick fields allowance near city area. Fourthly, public ignorance on air quality. Finally, breathing in polluted air imposes harmful effects on health.

1.7 Thesis Contribution

In the current stage of Dhaka city, three large flyover and one Metro Rail project is in under construction around Dhaka city. Construction work area of those site becoming a hazardous place for people due to piling, digging and drilling work. Furthermore, huge amount of traffic jam occurring each and every day in all over Dhaka city. Very harmful particle matter such as Sulfur, Nitrogen, Ammonia, Hydroxide are mixing with the air and the size of 2.5 micro gram weighted particle goes through human respiratory system and also causes skin cancer. From the burning fuel from those vehicles polluted the air with Carbon Dioxide, Carbon Monoxide and many other harmful gases. This report will contribute on those issue. This report will find out the amount of air pollutants in atmosphere. It will also find out which area is more polluted and what are the reason behind it. So that we can control the amount of that element on that particular area. Finally, develop a safe IoT based live map system.

Chapter 2

Literature Review

The major sources of air pollution are transportation engines, power and heat generation, industrial processes and the burning of solid waste. A new source of air pollution is an increasing 'hole' in the ozone layer in the atmosphere above Antarctica, coupled with growing evidence of global ozone depletion. Contamination in the atmosphere caused by the discharge, accidental or deliberates of a wide range of toxic substances. Often the amount of the released substance is relatively high in a certain locality, so the harmful effects are more noticeable. Air pollution has also long been known to have an adverse effect on human beings, plants, livestock and aquatic ecosystem through acid rain.

2.1 Historical Background

The age of Dhaka city is more than 400 years. Different times during last centuries our valiant freedom fighters made supreme sacrifice to protect Dhaka city and build a peaceful and beautiful place. In 37 years of independence the capital of Bangladesh, the historic city which bears many symbols of national pride like Language Martyr monument, Monument for martyred, freedom fighters, Historic relics of Mogul Dynasty unfortunately have become a concrete slum perspiring for fresh air & thirsty for pure drinking water. Everyday we have to live with various types of pollution like water pollution, air pollution, sound pollution. Over these years the population has increased many folds and become three times larger. Hunger, poverty increasing day by day. This is not what the liberation war was fought. People of Dhaka city are not fully realizing what crisis is emerging for them. Among all of those problem, air pollution is becoming alarming in all over the county.

There was a data of 1996, which can clearly shows the pollution level of Dhaka city.

	Particulate matter (PM10)	Hydrocarbons	Carbon Monoxide	Nitrogen oxides	Lead	Carbon dioxide	Methane
Light duty vehicles	0.26	3.70	24.91	1.63	0.012	309	0.04
Mini bus	0.21	0.12	0.30	0.58	0.003	115	0.02
Diesel bus	0.64	0.42	1.40	2.65	0	324	0.02
Diesel truck	1.11	0.74	1.91	3.61	0	563	0.03
3-wheeler	0.93	13.52	16.37	0.07	0.011	147	0.19
2-wheeler	0.55	3.31	5.81	0.02	0.011	50	0.11
Total	3.70	21.80	50.70	8.55	0.037	1507	0.40

Figure 2.1: Air Pollution Index of Dhaka City in 1996

Air pollution in Dhaka is serious because of increasing amount of population and related mechanization. Beginning evaluations uncover that engine vehicles every year produce 3,700 tons of particulate matters (PM10), 8,550 tons of nitrogen oxides, 50,700 tons of carbon dioxide, and so forth. 3-wheeler taxis are the critical supporters of air pollution. Two strokes motor vehicles contaminate seriously as far according to vehicle per kilometre driven. An ordinary taxi is driven 100-120 kilometres for each day. Therefore, in 360 days of a year, Dhaka's 80,000 in number taxis (¡17% of aggregate vehicles) are in charge of 25% of aggregate vehicular PM10, 62% of hydrocarbons, and 32% of carbon mono oxide [4].

2.2 Theory Relevant to Research Hypotheses

Air pollution has become a matter of great concern for us in recent years. Those who are living in cities in Asian countries including Dhaka have already realized how seriously air pollution has been poisoning life and degrading the environment. The Environment Conservation Act, 1995 and the Environment Conservation Rules, 1997 have been enacted by the Parliament. Emissions from diesel engines are smoke, carbon monoxide, un-burned carbon, nitrogen oxides and sulphur dioxide. People living in major towns of Bangladesh experience the problems of air pollution in varied degrees. Good governance helped curb air pollution in cities like Bangkok, Kolkata, Kathmandu and Lahore while weak administration caused the increase of air pollution in Dhaka and Karachi. Under the Rules of 1997, Ambient Air Quality Standards, Vehicular Exhaust Emission Standards, River Transport (Mechanized) Emission Standards and Gaseous Emission for Industries or Projects Standards have been set. Industrialization and mechanized vehicles are two major sources of air pollution in any country.

2.3 Current Literature Relevant to Research Hypotheses

On 13th March 2019, The High Court asked both Dhaka north and south city corporations to submit reports before it on their steps taken to prevent air pollution in Dhaka. They submitted the report of air pollution elements. The report shows that in an average Dhaka city has fetching 147 PM10 particles while the acceptable level is 40. But the court said that the DoE's action is not adequate as the air pollution was not reduced in Dhaka city. While hearing the petition, the court said they are

disappointed as "the authorities did not take proper action for preventing the air pollution". In the report, the DoE said it has conducted mobile courts against the persons who are responsible for air pollution. Earlier in the day, the DoE and city corporations placed some reports before the HC in line with its January 28 order [3].

Recently Ministry of Environment and forest has introduced "Clean Air and Sustainable Environment (CASE)" Project to monitor air quality index. This project is aimed to

1. To strengthen capacity to plan, monitor, regulate and implement Sustainable Environmental Initiatives (SEIs) in transport and brick making industries,
2. To reduce emissions from the brick making industry,
3. To reduce congestion by improving traffic flows,
4. To lay the foundation for reforming the existing bus operations and to introduce Mass Transit such as Bus Rapid Transit (BRT) in capital Dhaka in line with Strategic Transport Plan (STP) of the government,
5. To provide the institutional and regulatory underpinning for initiating bus sector reform and reduce vehicular emissions,
6. To strengthen the institutional capacity to implement Sustainable Urban Transport (SUT) intervention, and
7. To enhance the capacity to anchor the implementation of various project components.

2.3.1 National Ambient Air Quality Standards for Bangladesh

CASE project monitors the criteria pollutants such as carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, PM10 and PM2.5 in our living air. The main purpose of this report is to present, analyze and make available of these data to the general public, stakeholders, researchers and policy makers to develop effective air pollution abatement strategies. Monitoring is performed to demonstrate attainment or non-attainment of national ambient air quality standards to assess the trends of air pollution levels. This report summarizes the air quality data collected at the different CAMS in operation under the Department of Environment (DoE) air quality monitoring network. The basis for discussion of air quality has been the data collected from the Air Quality monitoring Network stations under DoE. The data have been quality controlled and the air pollution levels have been compared to the Bangladesh Ambient Air Quality Standard as adopted in 2005. Table 2.1 represents the current and approved air quality standards for Bangladesh [7].

Notes:

(a) Not to be exceeded more than once per year
(b) The objective is attained when the annual arithmetic mean is less than or equal to 50 micro gram/m3

Ambient Air Quality Standard		
Pollutant	Objective	Average
CO	10mg/m3(9 ppm)	8 hours(a)
CO	40mg/m3(35 ppm)	1 hour(a)
Pb	0.5micro gram/m3	Annual
NOx	100micro gram/m3(0.053 ppm)	Annual
PM10	50micro gram/m3	Annual(b)
PM10	150micro gram/m3	24 hours(c)
PM2.5	15micro gram/m3	Annual
PM2.5	65micro gram/m3	24 hours
O3	235micro gram/m3(0.12 ppm)	1 hour(d)
O3	157micro gram/m3(0.08 ppm)	8 hours
SO2	80micro gram/m3(0.03 ppm)	Annual
SO2	365micro gram/m3(0.14 ppm)	24 hours(a)

Table 2.1: Ambient Air Quality Standard

(c) The objective is attained when the expected number of days per calendar year with a 24- hour average of 150 micro gram/m3 is equal to or less than 1
(d) The objective is attained when the expected number of days per calendar year with the maximum hourly average of 0.12 ppm is equal to or less than 1 (Source: Air Quality Monitoring Project, Department Of Environment) [7].

2.4 Ambient PM concentration in Dhaka City

The CASE project has been monitoring ambient air quality at three sites in Dhaka city; the sites are (1) Parliament premises, (2) Bangladesh Agricultural Research Council (BARC) premises, Farmgate, and (3) Darussalam, Mirpur. Five (05) criteria air pollutants (PM, SO2, NOx, O3, and CO) and useful meteorology parameters are being monitored every minute in the CAMS. Table 2.2 shows an overview of the PM concentrations in different years in Dhaka city. The concentrations are daily averaged, calculated when minimum 80% hourly concentration data was present in a day. Compared to 2013-14, Dhaka experienced about 12% lower PM concentration (annual) in 2017. This reduction in yearly PM concentrations in air may be attributed to the ongoing reforms in the brick kiln sector. A large number of FCK has been replaced with Zigzag technologies in the last 4-5 years as a result of the adoption of the Brick Manufacturing and Kiln Establishment Act – 2013 (revised in 2018) [8].

Table 1 Overview of daily PM concentrations in Dhaka in recent years; daily concentrations are determined when minimum 80% valid hourly data is available in a day

Year	PM_{10} Conc. ($\mu g\ m^{-3}$)						$PM_{2.5}$ Conc. ($\mu g\ m^{-3}$)					
	Data capture rate %	percentile				mean	Data capture rate %	percentile				mean
		25	50	75	95			25	50	75	95	
2013	90.7	66	122	221	394	161.4	87.6	32	57	127	259	92.0
2014	82.2	66	120	237	393	159.4	86.5	34	70	145	236	95.0
2015	62.7	80	160	254	349	172.8	90.0	35	62	143	222	90.0
2016	69.3	58	98	214	395	145.1	64.0	28	44	92	211	68.0
2017	85.7	65	103	207	362	142.6	85.5	34	53	118	200	80.5

Figure 2.2: Overview of daily PM concentration

2.5 Air Sampling of Monitoring of Lead(Pb)

The lead in the air sample was determined according to the NIOSH 7105 standard test method. A dust sampling starter kit including filter paper, sampling head, flow meter, air sampling pump and other accessories were used for the analysis of Pb in air samples. First air samples were collected in Mixed Cellulose Esters (MCE) Filters (Diameter: 25millimeter, Pore Size: 0.8 micro meter) using a Casella APEX air sampling pump. MCE membrane filters are readily soluble and one of the most widely used filters for atomic absorption analysis. Sampling was done at an accurately known flow rate 3.5 L/Min up to 8 h for a total sample size of 1 to 1500L [6].

Chapter 3

Method

In this thesis work i have chose a very simple method to find out the sufficient amount of air pollutants present in Dhaka city air. First I have developed a simple Arduino Uno based sensor module for collecting air pollutant elements using MQ2 and MQ135 sensors.

3.1 Study Area and Software Selection

Department of Environment (DOE) of Bangladesh monitors the quality of air in this country through Dhaka US Consulate Air Pollution real time air quality index, strategically located in Baridhara, industrial and residential areas. Any significant change in the quality of air which may deteriorates human health and the environment can be detected.

This research concentrates on analyzing air quality in Dhaka city from 1st February to 20th April 2019. The dates are particularly chosen based on availability of low air quality data. Seven to eight main areas are identified to be included in the study: Uttara(Dia Bari), Tongi College gate, Badda Notun Bazar, Rampura TV Center, Shahbag and Mirpur Circle were the targeted area. The reasoning is that high traffic and heavy industrial and development activities encompass these areas. Figure 3.1 shows the map of Dhaka and the locations of these stations.

3.1.1 Software Selection

For this project I have selected ArcGIS Pro software and ThingSpeak online software to insert the collected data. Figure 3.2 shows the ArcGIS Pro software interface.

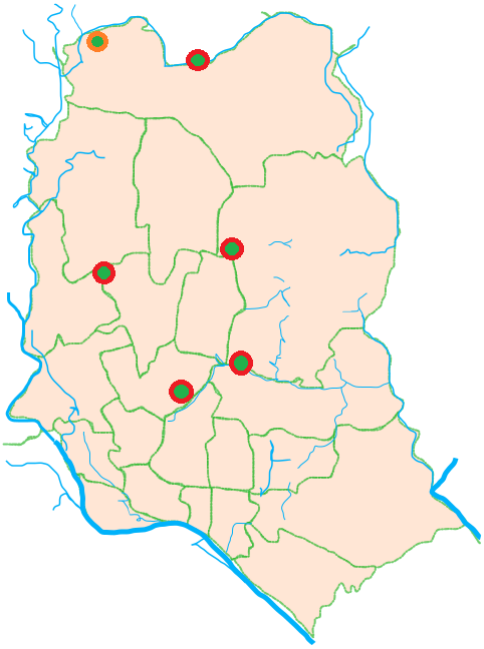


Figure 3.1: Dhaka city map and study areas

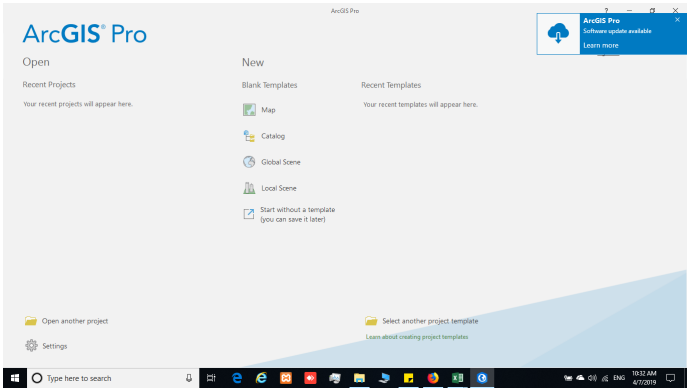


Figure 3.2: ArcGIS Software Interface

3.2 Device Introduction

3.2.1 Arduino Uno

The Arduino Uno is an open-source micro controller board based on the Microchip ATmega328P micro controller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output pins that may be interfaced to various expansion boards and other circuits. The Arduino Uno is a strong microcontroler which can be used to control many hardware based project using its own coding format and library. The following figure 3.3 represent a generic type of Arduino Uno device.

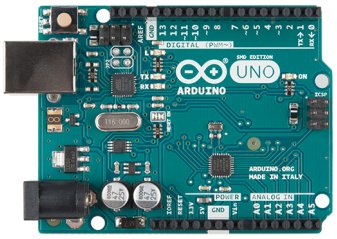


Figure 3.3: Arduino Uno Generic

3.2.2 MQ2 Sensor

MQ2 is a basic Gas sensor, which can detect some elements present in air like LPG, Alcohol, Propane, Hydrogen, CO, Methane etc. from a range of 0ppm to 10000ppm.

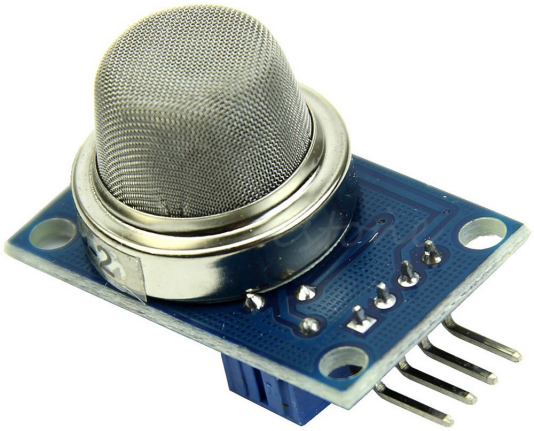


Figure 3.4: MQ2 Sensor

It has some basic features:

1. It can operate on 5V.
2. The Analog output is 0V to 5V
3. The Digital Output voltage is also 0V or 5V (TTL Logic)
4. It can preheat within 20 seconds
5. It can be used as a Digital or Analog sensor
6. The Sensitivity of Digital pin can be varied using different range of potentiometer

3.2.3 Where to use MQ2 Gas sensor

The MQ2 Gas sensor can detect or measure gasses like LPG, Alcohol, Propane, Hydrogen, CO and even methane. The module version of this sensor comes with a Digital Pin which makes this sensor to operate even without a micro controller and that comes in handy when trying to detect one particular gas. When it comes to measuring the gas in ppm the analog pin has to be used, the analog pin also TTL driven and works on 5V and hence can be used with most common micro controllers.So if we looking for a sensor to detect or measure gasses like LPG, Alcohol, Propane, Hydrogen, CO and even methane with or without a micro controller then this sensor might be the right choice for us [10].

3.2.4 MQ135 Sensor

MQ135 is a basic Gas sensor,which can detect some elements present in air. It can detect NH3, NOx, Alcohol, Benzene, Smoke, CO2 etc. from a range of 0 PPM to 10000 PPM.

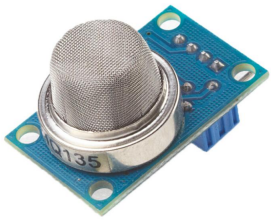


Figure 3.5: MQ135 Sensor

It has some basic features:

1. It has wide detecting scope.
2. It has a fast response and high sensitivity of detection
3. It is more stable and has a long life
4. Like MQ2, the operating voltage of MQ135 is +5V
5. It's analog output voltage is 0V to 5V
6. The digital output voltage is 0V or 5V (TTL Logic)
7. It also preheat in 20 seconds
8. It can be used as a digital or analog sensor to detect air quality
9. The Sensitivity of Digital pin can be varied using different range of potentiometer

Where to use MQ-135 Gas sensor

The MQ135 Gas sensors are used in air quality control equipment's and are suitable for detecting or measuring of NH3, NOx, Alcohol, Benzene, Smoke, CO2. The MQ-135 sensor module comes with a Digital Pin which makes this sensor to operate even without a micro controller and that comes in handy when trying to detect one particular gas. If we need to measure the gases in PPM the analog pin need to be used. The analog pin is TTL driven and works on 5V and so can be used with most common micro controllers. If we looking for a sensor to detect or measure common air quality gases such as CO2, Smoke, NH3, NOx, Alcohol, Benzene then this sensor might be the right choice for us [9].

Calculate Resistance of MQ135

$$Resistance(RS) = (Vc/VRL - 1)RL \tag{3.1}$$

Once we calculate Rs and Ro we can find the ratio and then using the graph shown above we can calculate the equivalent value of PPM for that particular gas.

3.2.5 ESP8266 wifi Module :

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and micro controller capability produced by manufacturer Espressif Systems in Shanghai, China. The chip first came to the attention of western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer AI-Thinker. This small module allows micro controllers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at first there was almost no English-language documentation on the chip and the commands it accepted. The very low price and the fact that there were very few external components on the module, which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation. The ESP8285 is an ESP8266 with 1MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi. The successor to these micro controller chips is the ESP32, released in 2016.

3.2.6 Work flow

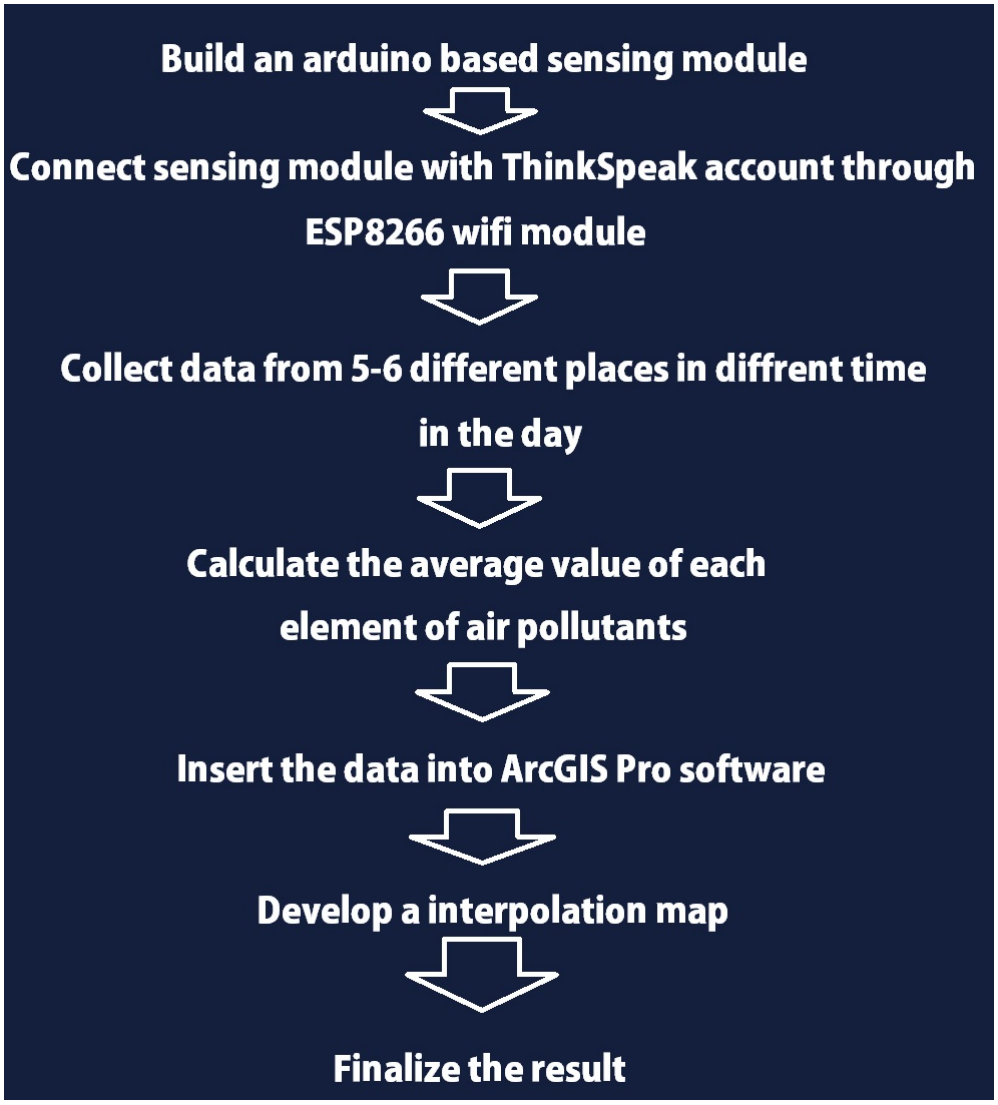


Figure 3.6: Work flow

3.2.7 Details Working Procedure

Build Arduino based module :

At first I have bought the necessary sensors from local electronic market. The basic components are required for this project is Arduino Uno device, ESP8266 wifi module, potentiometer, some jumper wires, buzzers, LEDs and other basic components. Then I have designed such a module which is simple and easy to carry from one place to another. The following figure 3.7 shows the basic connection between sensor and Arduino Uno. The Arduino UNO microcontroler is used for run the whole system.

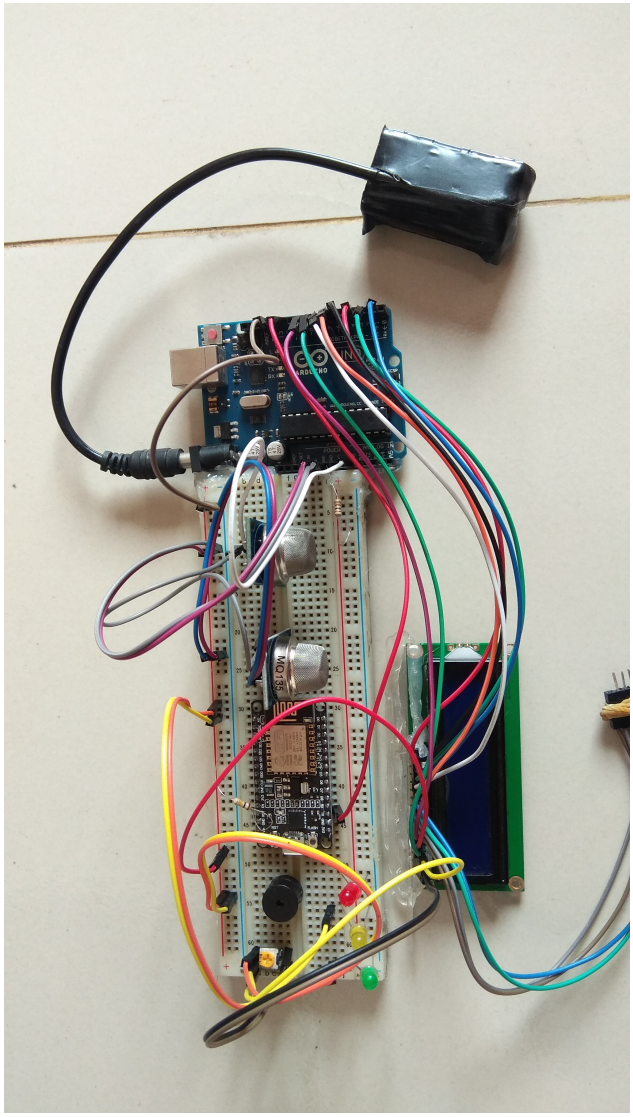


Figure 3.7: Sensing Module

Connect with ThingSpeak Account:

With the help of ESP8266 wifi module my data can be stored into cloud storage using internet. So I have created an account in cloud storage platform ThingSpeak and got an write API KEY, that key was used as a reference ID to insert collected data directly to ThingSpeak account through wifi communication. Here 3.8 Write API Key is that required key.

Collect Data from different places:

Then I collected data from seven different places throughout whole day or two full days in Dhaka city. First from Uttara Diabari area where the main station of Metro Rail project work is in under construction. That area is heavily polluted by some poisonous material like Sulfur,Nickel,Carbon etc. In there the project pilling, digging, dazing work is going on. As a result, those heavy material is mixing with air as PM2.5. Next area was Uttara House Building area where the Mass Rapid Transport work going on and millions of vehicles passes through that road everyday. Huge

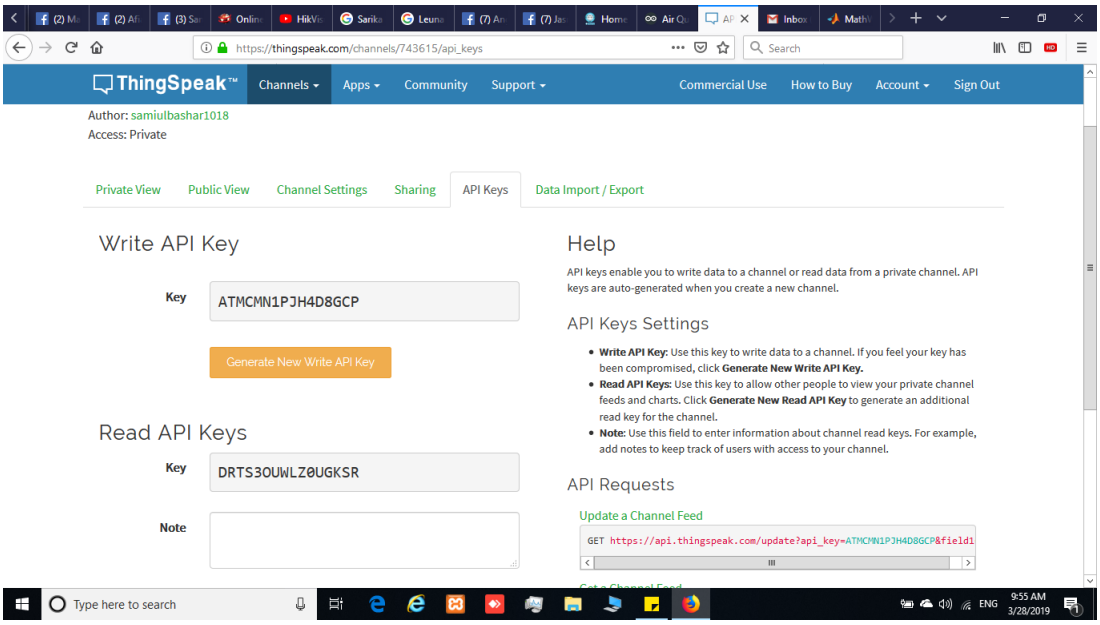


Figure 3.8: ThingSpeak API Key

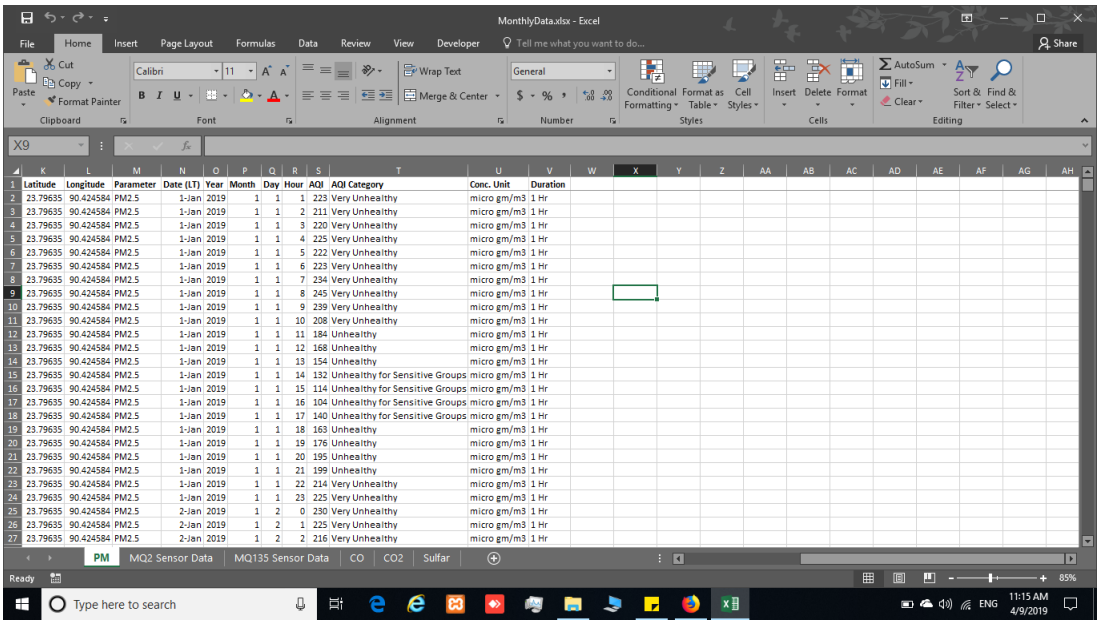
pollution is occur due to burning fuels like diesel,petrol,CNG etc. And thus produce Carbon Monoxide,Carbon Dioxide etc. Third area was Tongi Bazar area. Several Bricks fields, heavy industries, chemical factories are situated in this area. Wastage materials from those factories mixes with air particle and pollute air. Forth area was Rampura TV center and Badda Notun Bazar area. That area is also polluted with industrial wastage and smoke from vehicles. Fifth area is Mirpur circle area. Millions of vehicles passes through that area and the Metro Rail construction work is under construction. Thus pollute air due to Carbon Dioxide. Next area is Shahbag and Gulistan area. Those area is also highly polluted area due to heavy traffic, chemical factories, industrial production. Lastly from Buriganga River area. The most polluted area of Dhaka city is this area. All chemical wastage goes towards Buriganga river. Millions of industrial factories situated here. Many chemical and fertilizer factories established here. Those mills and factories pollute air by using harmful materials. All those area are highly polluted are due to construction work, burning fuel from huge number of vehicles, some chemical and industrial factory. I have also collected data from some other places for short amount of time. Those data has included in my report as a findings.

Compare with the Dhaka US Consulate Data:

I have collected the daily data of last 4 months from National Air Pollution Monitoring System of Bangladesh, which is US Consulate form American Embassy. The average value of PM 2.5 was 193ppm whereas my collected data was around 178ppm.

Calculate Average value:

Then I have calculated the average data from my collected data. The average value of PM2.5 was around 178ppm and PM10 value was around 243ppm.



Latitude	Longitude	Parameter	Date (LT)	Year	Month	Day	Hour	AQI	AQI Category	Conc. Unit	Duration
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	1	223	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	2	211	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	3	220	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	4	225	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	5	222	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	6	223	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	7	234	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	8	245	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	9	239	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	10	208	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	11	184	Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	12	168	Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	13	154	Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	14	132	Unhealthy for Sensitive Groups	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	15	114	Unhealthy for Sensitive Groups	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	16	104	Unhealthy for Sensitive Groups	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	17	140	Unhealthy for Sensitive Groups	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	18	163	Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	19	176	Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	20	195	Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	21	199	Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	22	214	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	1-Jan	2019	1	1	23	225	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	2-Jan	2019	1	2	0	230	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	2-Jan	2019	1	2	1	225	Very Unhealthy	micro gm/m3	1 Hr
23.79635	90.424584	PM2.5	2-Jan	2019	1	2	2	216	Very Unhealthy	micro gm/m3	1 Hr

Figure 3.9: Dhaka US Consulate Data

Insert data in ArcGIS Pro Software:

Then i have inserted the data into ArcGIS Pro software and also add a base map of Dhaka city in (.shp) format. Then with the help of IDW interpolation tools I have develop a map.

Develop Map and Finalize result:

The initial map was very simple and easy to understandable. In this map the average annual amount of PM2.5 was around 186 and the the average value of PM2 was 2013. The average rate of Carbon Monoxide was 8.

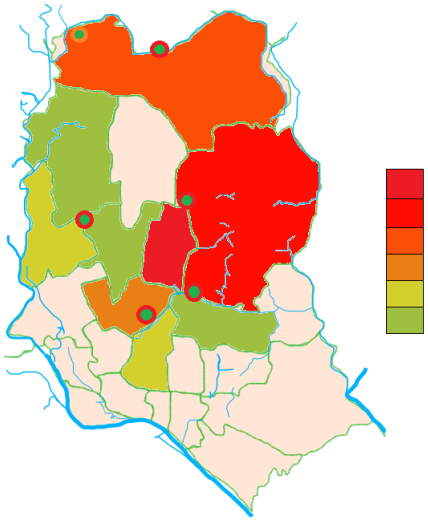


Figure 3.10: More Polluted Area of Dhaka City

Chapter 4

Result and Conclusion

The aim of this project was to develop such a model which can find out the air pollution elements concentration in our living air. According to World Health Organization the air quality level has divided into six levels. Those level indicates the quality of air due to the percentages of pollutant present on air. Those levels are:

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health warnings of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects.

Figure 4.1: Air Quality Index Level

Therefore, from the result that I have found in my research, the air quality of Dhaka city is Completely unhealthy for live because the level is 151-200. My collected data has shown in table 4.1.

4.0.1 Conclusion

To conclude the thesis report I can state that, the city where we lived is becoming Unhealthy for us everyday. Figure 4.2 shown the air quality index of 24th April 2019. People's health, especially those who are the most vulnerable, such as children, the elderly and the sick, is at risk from air pollution, but it is difficult to say how large the risk is. It is possible that the problem has been over-stressed in relation to other challenges in the field of public health. For this reason alone, local authorities could take action to assess and improve local air quality. However, the old and the young,

Area wise collected data(Average of 30 days)			
Area	CO(ug/m3)	CO2(ppm)	AQI(ppm)
Uttara(Diabari)	621	397	247
Uttara(House Building)	610	406	213
Tongi Bazar	661	429	278
Khilkhet	598	392	194
Notun Bazar	648	441	259
Badda	657	424	273
Shahbag	604	438	232
Mirpur Circle	646	472	279

Table 4.1: Concentration of air pollutants in different location

and especially those suffering from respiratory or heart diseases, are the groups who are most vulnerable to the effects of air pollution. Another reason for action on air pollution is that we do not know the contribution which exposure to air pollutants may make to deaths from, for example, heart disease. In many countries heart disease is a leading cause of death and even a small contribution from air pollution could mean a significant and important effect on public heath. So we need to be more careful about the air pollution issue and find out a suitable solution for it. So that, our future generation can breathe in fresh air.

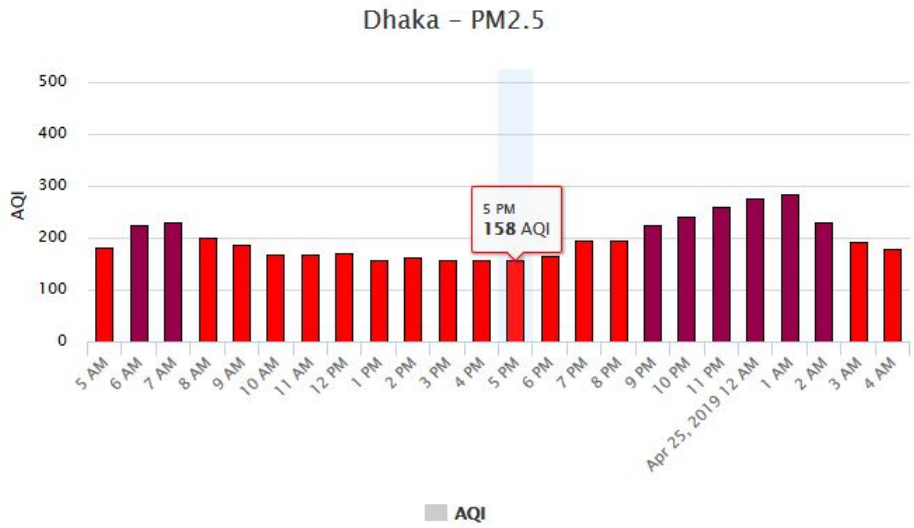


Figure 4.2: Air Quality Index Level of Dhaka city

4.0.2 Effect of Air Pollution

In our present air, different types of pollutant gases are mixing with fresh breathable air. Those gases are very harmful and dangerous for both human and animal life. Those gases are-

Carbon Dioxide

CO2 is colourless, odourless gas and non-combustible gas. Generally CO2 levels of outdoor air are under 350ppm. But in our country it goes up to 500ppm. Which is more dangerous of human health. Moreover, it is considered under the category of asphyxiate gases that have capability of interfering the availability of oxygen for tissues [1].

Carbon Monoxide

CO is odourless, colourless, tasteless and highly poisonous gas. Continuous exposure of CO even at low levels can cause depression, confusion, and memory loss. Half-life of CO gets shortens from 320 minutes to 80 minutes on normal air by managing oxygen via non-rebreathe mask. In addition, after combining with the hemoglobin of blood, it forms carboxyhaemoglobin (HbCo) which leads to reduction in oxygen carrying capacity of blood thus causes hypoxia. Human health is largely in danger with the exposure to 100ppm or more. It is released when fuel in engine does not burn properly and road traffic is the primary source of 91% of all CO emissions

Smoke

About 1 million people are in habit of tobacco smoking globally of which majority population is from developing countries. Every year nearly 4.9 million people died due to smoking according to 2007 report. In addition, second hand smoke is serious threat to the health of people of all age's causes 41000 deaths each year. On the other hand fuel burned smoke emission from faulty vehicles, brick kilns has a rapid action on human respiratory system. Sometimes it damaged the lungs completely.

LPG

Liquefied petroleum gas (LPG) is an odourless and colourless liquid which evaporates readily into a gas. Gas leads to burn or explode after getting in touch with a source of ignition. LPG may leak in the form of a gas or a liquid. If it leaks in the form of a liquid it evaporates quickly and will eventually form large cloud of gas in air which is relatively heavier than air thus drops to the ground. It has also impact on human health [2].

Discussion

Air pollutants are increasing in the Mega city of Dhaka in Bangladesh. This is an awful threat for the sustainable living of human beings in this city. People have been facing various diseases due to the increase of toxic air pollutants. Air pollutants such as, volatile organic compound (VOC), carbon dioxide(CO2), carbon monoxide(CO), oxygen (O2), sulfur dioxide(SO2), nitrogen oxide (NOx), hydrogen sulfide (H2S), suspended particulate matter(SPM), particulate matter(PM10), and particulate matter (PM2.5) have increased significantly in Dhaka. Due to the increasing levels that exceed the standard limits of each pollutant, different health concerns

have developed among the community people in this city. In this manner, rate of mortality has been increasing also. As a result, research on air quality parameters and their impacts on human health are absolutely important. It is expected that the monitoring of air quality parameters regularly and discovering their impacts on a sustainable environment will provide standard guidelines for the improvement of urbanization in relation to the sustainable livelihood[6].

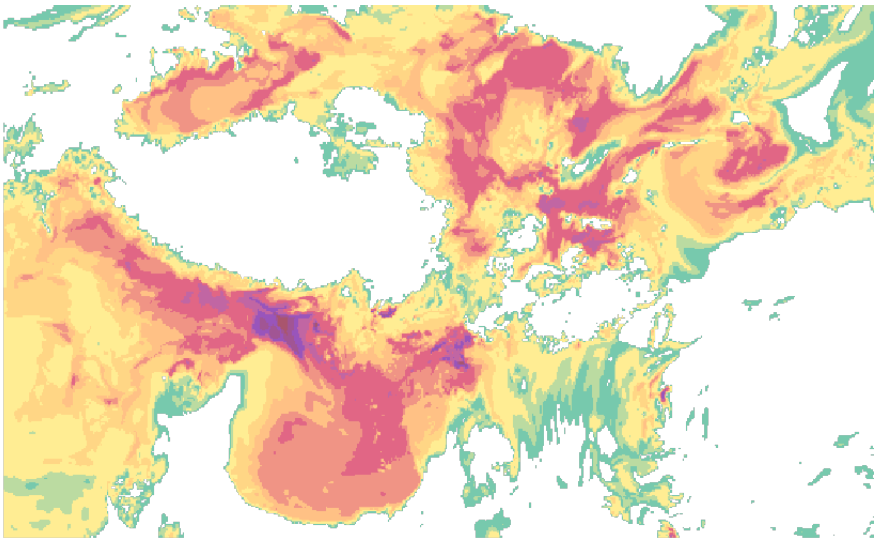


Figure 4.3: Air Quality Index

4.0.3 Future Work Plan:

Every thesis have change for better improvement. My future plan is to develop this prototype in a large scale, so that it can detect more precise result. All these sensors used in this project, has a limitation of coverage range. There are few powerful sensors available in foreign countries. If we can bought those sensor in cheap cost, there might a chance we get exact result. Due to time limitation I could not calculate amount of individual elements of air pollutants. For more precise result this project should collect at least 6 months continuous data. After that we can find a mean value and make exact decision about which particle is responsible for which area.

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How to install ArcGIS

Windows OS

Download

1. The first step to get started with ArcGIS Pro is to download and install the application. There are also optional setups available that provide offline help and language packs that allow you to run ArcGIS Pro in your preferred language. You can get ArcGIS Pro if you're current on maintenance for ArcGIS Desktop, or download the ArcGIS free trial.

2. Review the ArcGIS Pro system requirements to verify operating system and other environmental prerequisites.

3. Download ArcGIS Pro and any optional setups from My Esri. To download, your Esri account must be connected to your organization with the appropriate permissions. If you don't have appropriate permissions, the option to download will not be available to you. On the My Organizations tab in My Esri, click Request permissions to your organization, which will notify your administrator to connect your Esri Account to your organization.

4. ArcGIS Pro (required): Download from My Esri to get the main ArcGIS Pro application.

5. Offline Help (optional): Download from My Esri to access offline help (local help files) for ArcGIS Pro. By default, ArcGIS Pro connects to and displays an online help system. If you will be working in a disconnected environment, install the local help files.

6. Install ArcGIS Pro first.

7. Install any of the optional downloads.

or

Install

1. Start the ArcGIS Pro installation program and click Next when you are ready to proceed.

2. Review the license agreement and accept it if you agree. Click Next to continue with the installation. You must exit if you do not agree with the terms.

3. Select the installation context in which ArcGIS Pro will install, whether per machine (all users) or current user. By default, the per-machine option is selected. Click Next when you are ready to continue. (Note that if the user running the setup does not have administrative privileges, a per-machine instance of ArcGIS Pro cannot be installed.)

4. Click Change to specify the installation folder or click Next to accept the default location of C:Files(Note that if the installation folder is changed, neither ArcGIS nor Pro is appended to the modified path. It is recommended that the selected custom installation location include a folder and not the root location of a drive.)

5. Click Install to begin the installation. Note that the Esri User Experience Improvement check box is checked by default.

6. Click Finish to close the wizard when the installation completes. Leave the Run ArcGIS Pro now check box checked if you want to immediately start the application.

7. If needed, run the offline help setup for ArcGIS Pro by browsing to its installation folder and executing the ArcGISProHelp.msi file. This setup is needed to get offline help (local help files) for ArcGIS Pro. By default, ArcGIS Pro uses web-based help in a browser. If you will be working in a disconnected environment, install the local help files.

Authorize

1. After you download and install ArcGIS Pro, you must have an authorized license to begin using the application. If you have an ArcGIS Online or ArcGIS Enterprise portal account, you can start ArcGIS Pro with a Named User license. If your credentials do not work, contact your administrator because you may not have a license assigned to your username, or you may be using a different type of license than the default Named User license. If you are an administrator, the steps you follow to authorize your licenses depend on the type of license you are using. By default, ArcGIS Pro uses Named User licensing, but you also have the option to use Single Use or Concurrent Use licensing.