Environment Mapping and Air Purification System for Vehicular and Brick Kiln Emissions

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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 and Engineer

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Declaration

It is hereby declared that

1. The thesis submitted is our 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.
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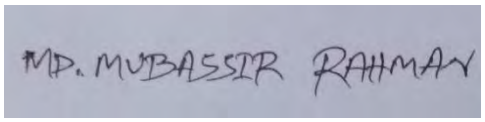

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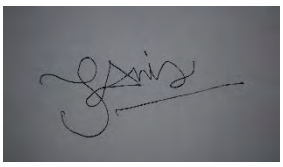

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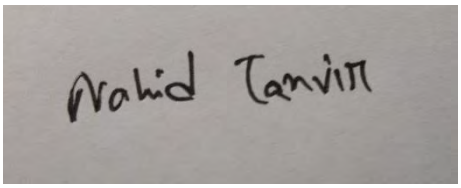

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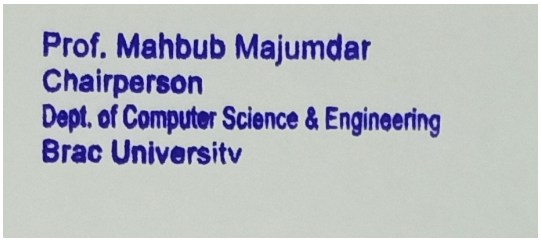

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Abstract

Air pollution is a very common environmental issue in our country. Moreover, this very environmental issue has numerous harmful side effects. The harmful effects can occur both to the outer environment and to the people. We plan to lower the effect of air pollution of Dhaka and the rest of Bangladesh by collecting data from the environment and taking steps to filter out the harmful and toxic elements from the vehicular emissions as well as emissions from brick kilns, especially carbon dioxide, from the air as much as possible and collect carbon for more beneficial purposes. We plan to use sensors on multiple vehicles and on brick kilns from factories to collect different sets of data from different routes to map the air quality fluctuation around the country. Moreover, we plan to use an efficient and user friendly solution to reduce carbon particles and carbon dioxide in the atmosphere by planting a filter device on the tailpipes of the vehicles and other sources like brick kilns.

Keywords: Air pollution, Vehicular emissions, Brick kilns, Sensors, Filter Device, Collect Data.

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Chapter 1 Introduction

1.1 Motivation

As we all know, air pollution is one of the major environmental issues in recent times. It is one of the causes of adverse health effects such as cancer, cardiovascular diseases and can result in high mortality rates. Generally high population density is a huge contributing factor of air pollution in cities and urbanized areas. This is where Dhaka, the capital of Bangladesh, comes to the spotlight. Dhaka is one of the most densely populated cities in the world. It has topped the index of the world's cities with the worst air quality and arguably 80% of air pollution is the result of automobiles emitting harmful particles in the air [10]. Our main drive is to lower air pollution of Dhaka and the rest of Bangladesh by collecting data from the environment. After collecting the data, we intend to take necessary steps to filter out the harmful and toxic elements from the vehicular emissions as well as emissions from brick kilns, especially carbon dioxide, from the air as much as possible. After filtering them out, we want to use the once harmful collected particles for more useful purposes. For environment mapping we have taken data from different places around the city at different days and times to reach as much accuracy as we could. And the data we have collected looks very interesting and alarming at the same time. Moreover, we plan to use sensors on multiple vehicles and brick kilns to collect different sets of data from different routes to map the air quality fluctuation around the country. Furthermore, theoretically we have come up with a solution to reduce carbon particles and carbon dioxide in the atmosphere by planting a filter

device on the tailpipes of the vehicles. We hope to reach our goal using IoT and cloud computing.

1.2 Problem Statement

Automobiles have made our lives easier and simpler by providing us with convenient ways of traveling anywhere. It saves a lot of time and effort. But it creates vari- ous problems caused by its emission. There are various health and environmental impacts of automobile emission. A study done by The New York Times shows that people who live within 500 meters from highways and major roads are more likely to suffer from respiratory illnesses [16]. They found conclusive evidence that asthma is caused by automobile emission. The emission creates carbon monoxide, smog, sul- fur dioxide, nitrogen oxide, lead, etc., different harmful components which can also harm other organs other than heart diseases [17]. These can cause lung problems, genetic mutation, birth defect, reduction in mental ability, increase in blood pres- sure, cardiovascular diseases and premature death. Emission of greenhouse gases is continuously increasing every year from automobiles and road transports contribute to almost 70 percent of all automobile emission [4]. In India automobiles are respon- sible for a big part of the total pollution and two third of them are contributed by two wheelers. Also many of the vehicles on the road produce more harmful gases than they are supposed to produce [3]. According to The Daily Star, Bangladesh has the most polluted air in the world and Dhaka is the second most polluted capital city, according to a study published in August, 2019. However, no constructive measure has been taken under consideration to fight this problem even though Bangladesh has been struggling with air pollution for long [9].
In Figure 1.1, we can see the comparisons of air pollution level in various capital cities in the world, including Dhaka [13].

Though the average air quality of Dhaka and the entire Bangladesh are different. The air in rural areas and other districts is much healthier than in Dhaka. That is why our primary focus is on Dhaka city and the excessive number of automobiles that is responsible for this kind of pollution. Here is another figure to show the depth

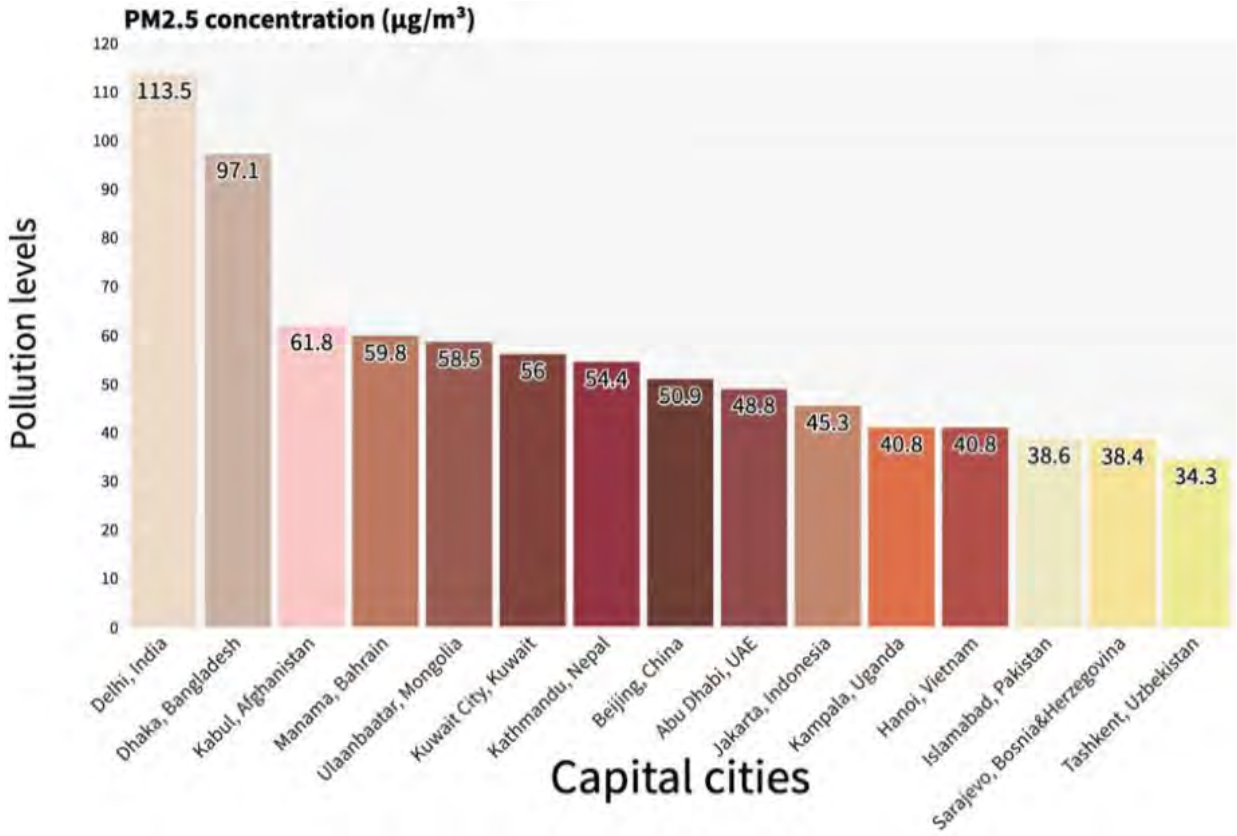


Figure 1.1: Pollution Level in Capital Cities

of harm that automobile's emission has been causing within the last few years.

In Figure 1.2, we can see the automobiles' emissions are more prevalent for air pol- lution than any other source around the city. Within this emission carbon dioxide removal and collection is our goal. There are so many harmful elements in the air like carbon dioxide, soot, smoke, mold, pollen, methane. Since carbon dioxide can numerous extreme diseases, we mainly intend to work with carbon dioxide. Being an ever pervading medium and carrier, air can transfer the pollutants very fast and makes it almost impossible for any person breathing in the polluted air, to avoid the infection **article13**. Though the pollutant level, reaction to the pollutants and infestation of the pollutant based diseases in every person is different; the fact that air pollution can have injurious effects on the human body can just not be ignored. Particulate matter like carbon can cause various kinds of diseases. Exposure to carbon dioxide can cause all the health problem that were mentioned before.

Moreover, carbon dioxide can also create a lot of unnatural problems when heavily

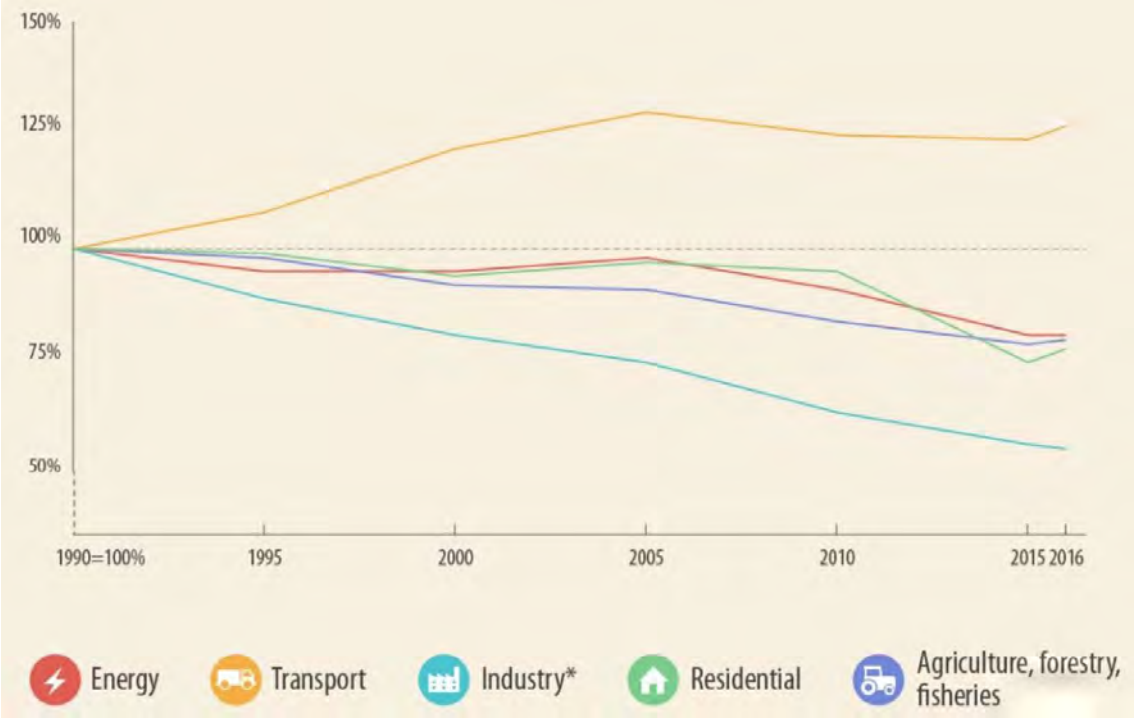


Figure 1.2: Depth of Air Pollution from Various Sources

emitted in the atmosphere. Carbon dioxide is generally needed in the atmosphere as it is a requirement by plants for photosynthesis. Photosynthesis helps plants obtain food and energy. Due to the increase in industries over time, the levels of carbon dioxide in the atmosphere keeps on rising. The main reasons for this increasing rise of carbon dioxide levels are deforestation and the burning of fossil fuels. As carbon dioxide levels continues to rise, its effects on air pollution also increase. Carbon dioxide accounts for less than 1 percent of the atmospheric gases. However, a deli- cate balance exists between carbon dioxide and other gases. The significant change of carbon dioxide over a relatively short period of time is of huge concern. Especially when it has a huge involvement in global phenomenon [12].

1. Greenhouse Effect: In terms of air pollution, carbon dioxide is heavily involved in the greenhouse effect [12]. Carbon dioxide is responsible for trapping radiation at ground level. This creates an ozone layer, which prevents the earth from cooling at night. This can cause the warming of ocean waters, which generally absorb carbon dioxide from the atmosphere. Due to the rise of water temperatures, the oceans become unable to absorb carbon dioxide. Which results in negative outcomes.

2. Climate Change: Carbon dioxide is also responsible for climate change, which can negative affect the environment. According to studies by the National Oceanic and Atmospheric Administration (NOAA), the surface temperature of Earth increased over the last 100 years. Scientists believe carbon dioxide pollution is the primary source of it. The effects are said to be highly complex. However, there are evidences which show that ocean water levels have increased, which resulted in a loss of shore- line and coastal wetlands [12].

3. Acid Rain: Carbon dioxide is also responsible for acid rain. Emissions that are released from fossil fuel-burning energy plants combine with moisture in the air [12]. By this, a highly acidic precipitation is formed. This acidic precipitation causes various physical damages to trees and other plant life. Moreover, water and soil pol- lution occur due to the acidic precipitation. Due to this effect of carbon dioxide, its impacts on air pollution should be taken more seriously.

4. Impacts on Human Health: Carbon dioxide emissions also affect human health by displacing oxygen in the atmosphere. Due to this, breathing becomes more difficult for a person due to decrease in oxygen levels. In closed areas, high levels of carbon dioxide can cause health issues like headaches. Carbon dioxide levels can also in- dicate high levels of other harmful air pollutants like volatile organic compounds, which contribute to indoor air pollution [12].

1.3 Research Objectives

With our project, we mainly intend to achieve two things. The first thing we al- ready achieved is allowing our device to detect carbon dioxide from the surrounding atmosphere. For this purpose, the specific things required are Arduino Uno R3, Gas Sensor Module (MQ-135) and Bluetooth Module Breakout (HC-05). The sensor in the device is required to detect the presence of carbon dioxide in the atmosphere and record all the data in PPM (particles per million). With the help of the Bluetooth module, all the recorded data is displayed on a smartphone via Serial Bluetooth

Terminal app. Compared to the weekends, we observed that the readings showed higher presence of carbon dioxide in the atmosphere due to higher number of vehi- cles on the road during the weekdays. Even during the days when not many vehicles were present, we saw that the readings indicated higher presence of carbon dioxide in the atmosphere during nighttime. This mainly happens because the plants do not perform photosynthesis at night.

Our next purpose is to effectively reduce carbon and carbon dioxide in the at- mosphere by creating a device that will block carbon and carbon dioxide from the automobile emissions and prevent from entering the atmosphere as much as possible. The device we plan to make will be fitted on the tailpipe of the vehicle. We plan to obtain the carbon particles using porous filter, and carbon dioxide in the exhaust will be absorbed using lithium hydroxide solution. [13] If lithium hydroxide solution is not available, we plan to use sodium hydroxide as a substitute. The carbon par- ticles obtained in the porous filter can be used to create industrial inks that can be used for multiple purposes like being used as ink for pens and printers. The lithium hydroxide solution used to absorb carbon dioxide will react with the carbon dioxide and form lithium carbonate, which can later be used to produce carbon nano-fiber and even fresh oxygen for the atmosphere.

1.4 Summary of Contribution

We are confident that our work will be very helpful in terms of reducing air pollu- tion greatly. And we are also hopeful that our Thesis will greatly contribute in the following areas-

1. Extracting carbon dioxide and carbon from exhaust fumes in an efficient manner.

2. Making useful materials like ink and baking soda from the extract carbon and carbon dioxide.

3. Making our device cost effective, affordable and user friendly for people.

1.5 Thesis Orientation

1. Chapter 1 is our Introduction. It introduces our topic, our objective and our motivation.

2. Chapter 2 is our Literature Review. It briefly touches upon all the things that we researched for our project.

3. Chapter 3 has details of our Proposed Work Plan and planned implementation details.

4. Chapter 4 puts emphasis on the result and analysis of the data we received at different time from the environment and our ways of reducing air pollution with feasibility.

5. Chapter 5 focuses on our goal and a promising business model to achieve that goal.

6. Chapter 6 highlights on our theoretical work regarding the severe air pollution done by the brick kilns.

7. Chapter 7 shows the future of this project.

8. Chapter 8 draws the conclusion of this paper.

Chapter 2

Literature Review and Related Works

2.1 Literature Review

After an intensive reading of the learning materials we came to know that there is a few research going on for outdoor air purification system. Most of the papers we found for our research deal with air purification in closed environments. These indoor environments include underground garages and spacecraft systems.

In case of the underground garages, we found that since big garages usually contain a huge number of cars in an enclosed area, the exhaust released from the vehicles cannot get out of an enclosed garage. The air purification is necessary in order to make sure that the garage's environment does not become way too polluted by poisonous air, otherwise it would be impossible for any person to enter the place. One of the solutions for this is EHC filters. EHC filters are exhaust cleaner for temporary driving of vehicles in factories, ships, workshops, exhibition halls etc. Now, in the case of spacecraft systems, we know that human beings inhale oxygen and exhale carbon dioxide. So when the astronauts exhale carbon dioxide, this car- bon contaminated air is passed through the desiccant beds and adsorbent beds to remove the carbon from the air by providing the necessary amount of heat. As a result, fresh air containing a healthy amount of oxygen is produced making it safe for the astronauts to breathe. Due to the respiratory system of the astronauts, this

process is continuous. [5]. As we did our research to find any other works similar to ours, we found two projects. One of the projects for solving the air pollution problem in Asia was proposed in an Indian MIT spinoff company. This very project involves the creation of ink from vehicle exhaust. This can be done by attaching a device known as a Kaalink to the end of an automobile exhaust pipe. The Kaalink is required to filter and capture unburned carbon emissions from incomplete engine combustion. The technical details for the process are said to be largely mechanical and relatively straightforward [7]. Another of those projects for solving this sort air pollution by vehicular fumes is from the London-headquartered technology firm Sustainable Flow. Sustainable Flow launched a magnetic car device that supposedly reduces harmful carbon emissions by approximately 70%, and it helps motorists to cut their fuel bills by approximately 10% and it also helps in decreasing their carbon footprint. Here, three powerful hi-tech ceramic magnets are installed onto the air, coolant and fuel lines of the engine. This improves fuel combustion by lowering fuel viscosity and breaking it into smaller particles. This helps in raising the net surface area of the fuel, so the molecules burn from the surface, optimizing the combustion of the fuel and substantially lowering exhaust emissions [7].

2.2 Problems in the Existing Solutions

When it comes to both the Kaalink device and the magnetic car device by Sustain- able Flow, they only help in preventing carbon particles from the exhaust fumes to reach the outer environment [14] [11]. But carbon particles are not the only harmful elements that gets released through vehicular exhaust. So from our points of view, the aforementioned two projects do not exactly reduce air pollution by vehicle in an efficient manner.

2.3 The Ways Our Project Is More Efficient

Unlike the Kaalink device and the magnetic car device by Sustainable Flow, our device not only blocks the carbon particles, but it also helps in blocking the carbon dioxide from the exhaust fumes. When we attach our device to a vehicle's tailpipe, the carbon dioxide from the fumes reacts with the sodium hydroxide present in our

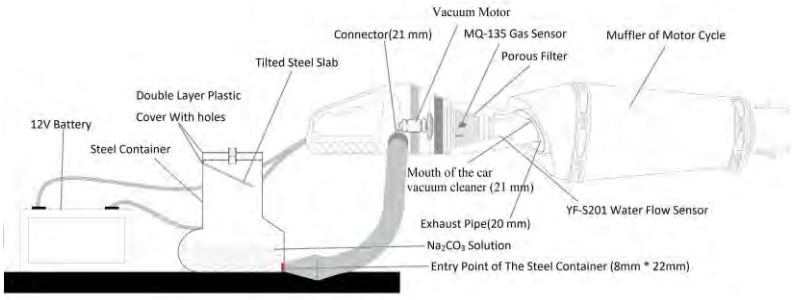
device to form baking soda (sodium bicarbonate) and water. Both baking soda and water formed can be used for other useful purposes. Moreover, we believe our device is supposedly cheaper and more affordable than both Kaalink and Sustainable Flow's magnetic car device. Since our device is more cost effective and can trap more harmful particles, we believe our device to be more efficient compared to the previous similar works.

Chapter 3 Proposed

Model

Before discussing the proposed model we would like to address all the major steps in this project. At first, we used MQ-135 Gas Sensor to detect the level of carbon dioxide gas present in the atmosphere at different situations of our day to day life. Then we used a model that is meant to absorb the unburnt carbon particles and the carbon dioxide gas from the combustion of fuel. Then we collected the by-product that our device has produced for further use. So if we define there would be three stages of this process and they are detection, absorption, collection. So before we go into the details of these stages Figure 3.1 shows a full drawing of the device model that we have been working on for this thesis purpose.

Figure 3.1: Full Drawing of Our Device Model



3.1 Detection

1. MQ-135 Gas Sensor:

For the purpose of measuring carbon dioxide output by vehicles we have used MQ- 135 Gas Sensor which can detect carbon dioxide, nitrogen oxides, benzene, alcohol, ammonia, etc. This sensor is widely used in various air quality control and monitor- ing devices in buildings, offices, factories, etc. There are many other sensors which can perform out desired work with varying accuracy. But this sensor was chosen as it has simple circuit with relatively high detection range, quick, reliable and stable reading capability, and also it has very long life span compared to its price. Though it might not have 100 percent accuracy when it comes to high frequency reading, it can still maintain more than enough accuracy over extensive period. Other lower priced sensors cannot do the works as reliably as MQ-135 and the more expensive ones can measure more types of particles and give readings of much higher range more frequently that we do not need in our work. SO, we choose MQ-135 Gas Sensor to measure the carbon dioxide emission by automobiles.

This MQ-135 Gas Sensor module has circuit voltage of 5V. Its Heating voltage is also 5V and heater resistance is 28 to 38 ohm which can be achieved in room tem- perature. Also its heat consumption needs to be not more than 800 mW. It needs less than 95 percent relative humidity and more than 2 percent oxygen in the air to operate. Ideally it requires around 22C temperature and around 65 percent humid- ity and need to be preheated for at least 20 seconds for optimal performance. There are total 6 pins on the sensor and 4 pins on the module. On the sensor there are two A pins, two B pins and two H pins. A and B pins cannot work together. Only one pair can give output while the other pair is grounded. The H pins are connected to Vcc and ground. The four pins on the module are called by corresponding numbers. Pin 1 and 2 are for Vcc and ground. Pin 3 gives digital output from the sensor and Pin 4 gives analog output. In our project we have used Pin 4 for analog output.

The sensor needs to be calibrated first for a long time before using it for the first time. We have used the code to do the calibration of our sensor. This is done to

enhance the accuracy of the sensor by finding zero calibration value. We then used the calibration value for real-time high frequency measurement of carbon dioxide us- ing another piece of code. This gives reading of carbon dioxide at 1000ms interval. The output unit is particles per million (PPM). We can get this value over wired or wireless connection.

2. YF-S201 Water Flow Sensor:

This sensor is very high quality compact sensor with great performance. It has a rotor inside which rotates when water or in our case high pressure vehicle fumes pass through the sensor. As the rotor rotates it gives pulse signal as output via a hall-effect sensor which is also placed inside the flow sensor. This sensor is used in different household and industrial machines. Its main applications are coffee machine, water heater, ATM machines and other flow management machines in fac- tories. Though we could choose any other cheaper sensors, there are two things that this sensor can provide which are very high tolerance in various aspects and its outer diameter. It can work between 4.5V and 18V. It can tolerate temperature between

-25C to 80C and the liquid can be as hot as 125C. Its relative humidity range is between 25 percent and 90 percent and can work in pressure as high as 2 MPa. All these high tolerance range makes it ideal for detecting the air flow coming out of vehicle exhaust pipe. Also the outer diameter of this sensor is 20mm which is same as the standard motor cycle exhaust pipe diameter. As a result it can perfectly fit into the tailpipe without any other external component. It has total three pins or cables two of which are for Vcc and Ground and one for output. We can use the sensor to find the flow every second in liter per minute unit.

3. HC-05 Bluetooth Module:

This is a V2 Bluetooth SPP Module which can be easily used to transfer data. It can send and receive data over 2.4 GHz band with up to 3 Mbps speed. So it is really good for us to receive data from sensors every second without even storing it on the device. This helps us getting real-time data in order to monitor both our

device as well as the vehicle's exhaust system. It has total 5 useable pins. Two of them are for power. TDX and RDX pins are connected with microcontroller's RDX and TDX pin and the 5th pin is used for switching mode.

4. Arduino Uno R3:

As microcontroller we have used Arduino Uno R3 the latest model of the Uno series. It is one of the cheapest microcontrollers on market which can perform our desired task with ease. It has 16MHz processor, 2048 bytes ram, 31.5 Kbytes program mem- ory and can operate between 7V to 12V. It has total 20 pins. 14 of them are digital I/O pins and other 6 are analog input pins. Figure 3.2 shows the how the system works.

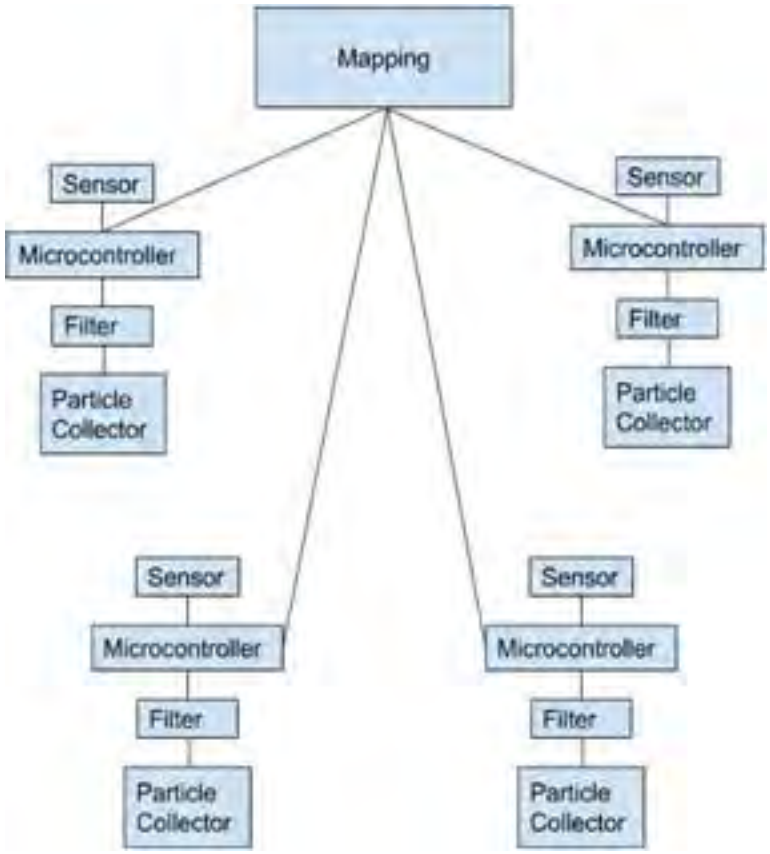


Figure 3.2: Full Drawing of Our Device Model

We plan to use GSM along with Bluetooth to collect data from the device in future. Data from every device can be sent to our server/database with the GPS location of the GSM device. These data are readings of carbon dioxide and air pressure from

the sensors. Then these data collected from all the devices can be used to map the environment as different vehicles move around the city.]

Figure 3.3 shows the real picture of the whole carbon dioxide mapping sensor device that we took with our phone camera.

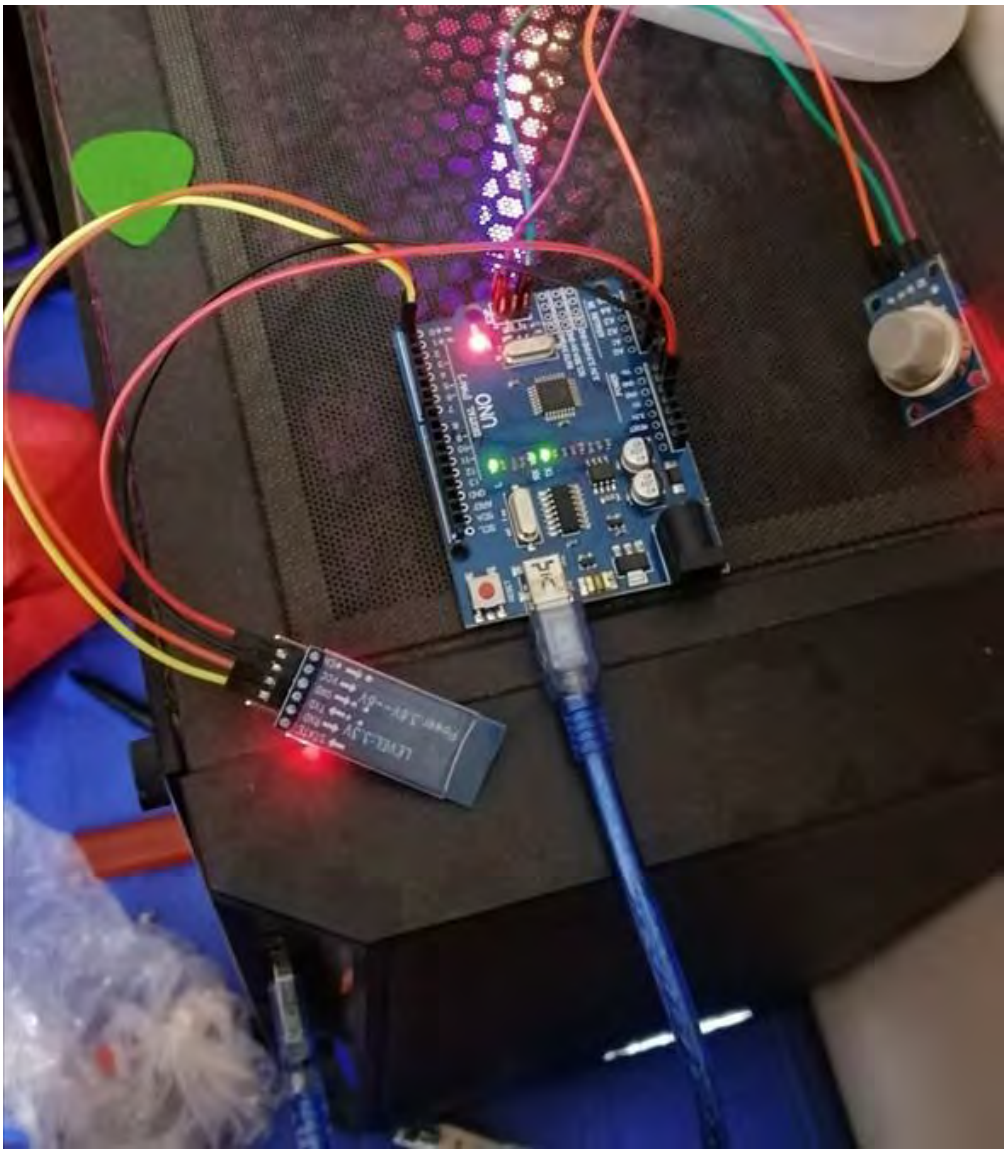


Figure 3.3: Carbon Dioxide Mapping Sensor

We can see the Bluetooth module and the MQ-135 gas sensor are attached with the Arduino board. In this photo the whole system is in calibration phase. The more we calibrated the system the more accurate result we got in the mapping. Figure

3.4 shows a photo of the MQ-135 gas sensor is also attached here.

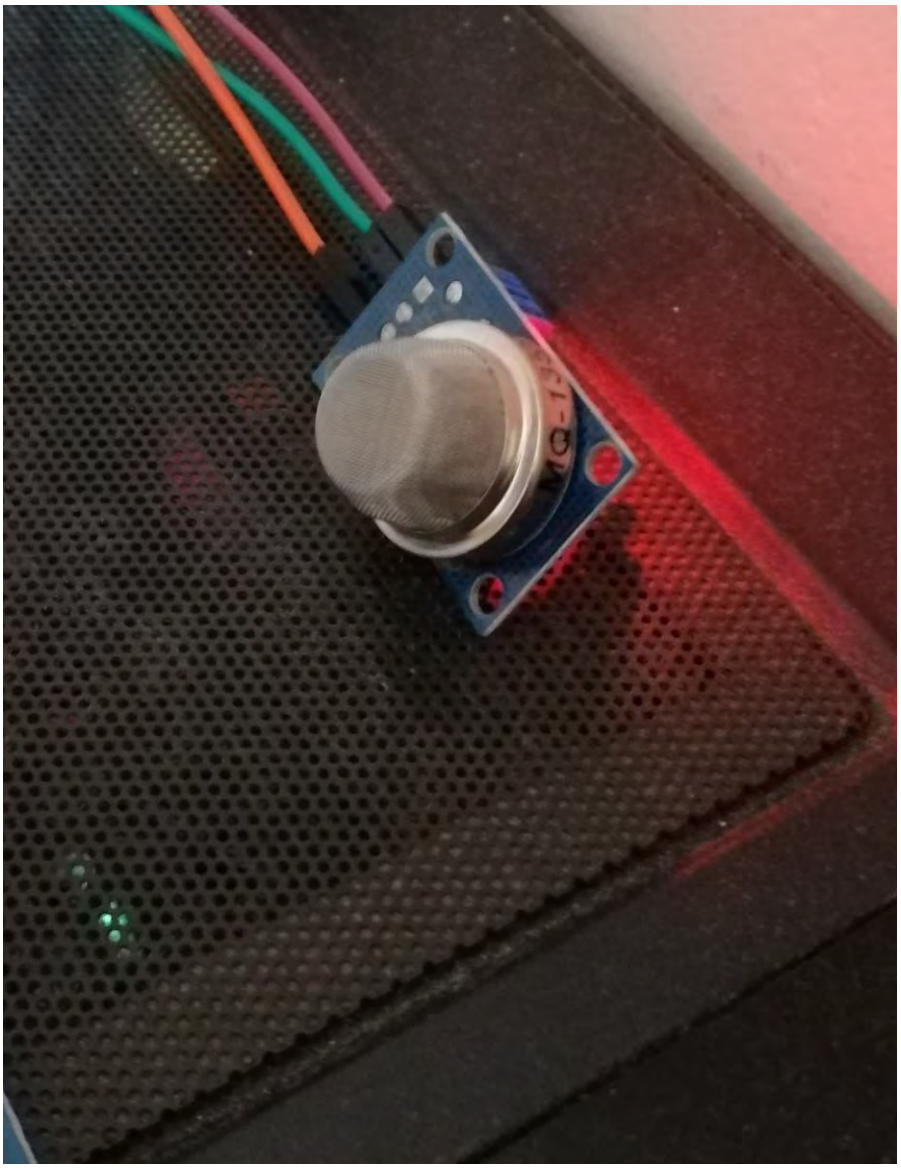


Figure 3.4: MQ-135 Gas Sensor

For now our device works following the flowchart in figure 3.6. The gas sensors serves the purpose of environment mapping and the give us the level of carbon diox- ide after going through the filter using. This is done by two MQ-135 gas sensors. One of them is used at the output opening of our device to take the reading and other is placed on the vehicle for environment mapping. The YF-S201 flow sensor on the other hand detects the flow of air inside the device and gives us warning if the air flow is lower than it should be. It can happen due to the porous filter filling close to its maximum capacity which indicates the porous filter need to be cleaned or replaced. Both of these sensors take reading once every second. The readingof

the gas sensor is send via Bluetooth for mapping while the reading of flow sensor is used for giving warning or notification for changing the porous filter.

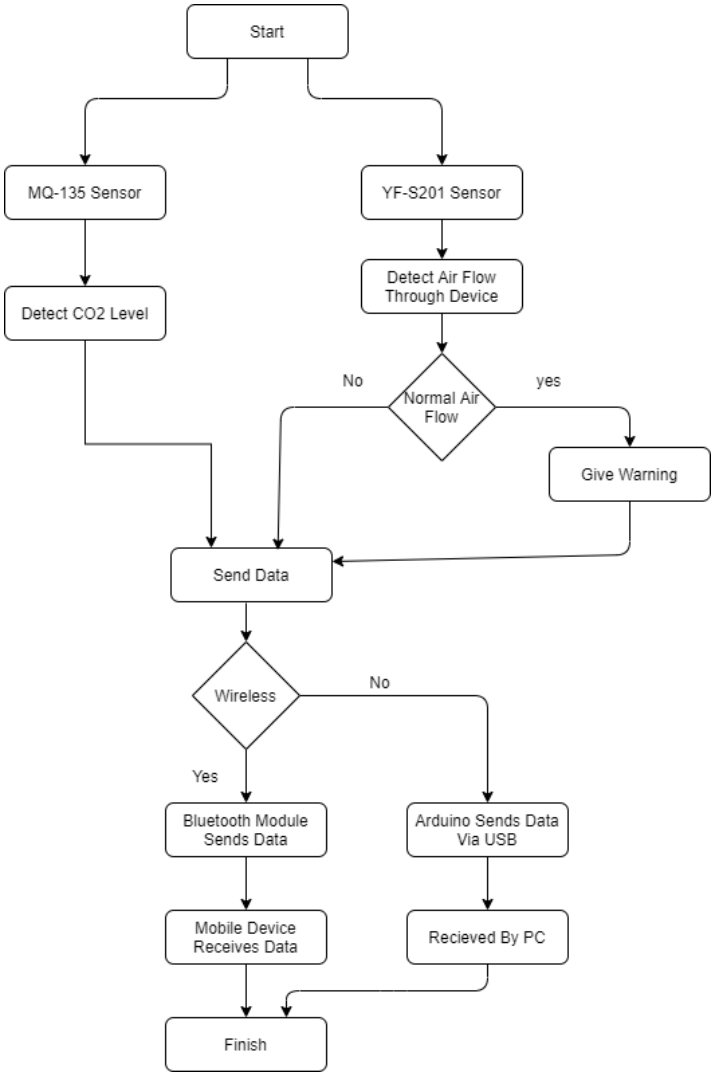


Figure 3.5: Flow Chart of How Our Device Works

3.2 Absorption

In the figure we can see that for the absorption phase we have attached a car vacuum on the exhaust pipe of the bike from where the emission would enter the vacuum cleaner. In this phase we faced a challenge that if there were excessive air pressure on the chamber it could harm the engine of the bike. However from the definition and formula of the pressure we know,

$$Pressure = \frac{Force}{Area} \tag{3.1}$$

So the air pressure drops at a significant level after it enters the vacuum cleaner as the diameter of the exhaust pipe is 20mm whereas the diameter of the chamber is 90 mm. Moreover, the vacuum motor of the cleaner also pulls the air from the exhaust pipe so that there is no extra pressure on the chamber or the pipe or the engine. There is a porous filter in front of the motor. So before leaving the chamber the emission first go through the porous filter where the unburnt solid carbon particle is absorbed and can be extracted later.

After the absorption of the carbon particles the rest of the emission goes through the vacuum cleaner and in the figure we can see that there is a hole right below the motor of the cleaner where we have attached a pipe and the pipe later enters the bottom of a steel container where we have kept a solution of sodium carbonate also known as washing soda and water. The emission which contains a high amount of carbon dioxide when it goes through this solution, reacts with the solution to produce sodium bicarbonate, which is also known as baking soda. The chemical reaction that is occurring in this process is shown below.

$$Na_2CO_3(aq) + CO_2(g) + H_2O(l) \rightarrow \quad 2NaHCO_3(g) \tag{3.2}$$

Here the steel container that we have used is 160 mm in length with a diameter of 100 mm on the top and 125 in the bottom. We curved the bottom part of the container to reduced splash. In the beginning of this experiment we faced a major problem with the splash that was produced when the emission entered the container and reacted with the solution. Later to reduce the solution we curved the bottom part of the container to use inertia produced by the force to stop the solution from reaching the top of the container. Inertia is a particle's will to move in a straight line. The greater the force is the greater the inertia. Moreover, we installed a tilted steel slab to counter even the slightest splash that is produced. The slab has a diameter of 90 mm. Even if some of the splash crosses it over it will come down and fall on the bottom because it is tilted downward. The size of the entry point in the

container is rectangular with a length of 5 mm and a width of 35 mm. Previously, we used a circular pipe with a diameter of 20 mm but with this the splash count was really high and the solution was not fully used in the container because some of the washing soda is always there in the bottom of the container. So to achieve the highest amount of result and to reduce the splash we used a thinner entry point and a pipe-head. Now on the top of the container we used a two layer plastic cover with multiple holes to let the rest of the gases out. This car vacuum cleaner is run by DC current so it can be run from the vehicles battery. Here we used a 12V battery for the experiment.

3.3 Collection

After the absorption phase we have to collect the solid carbon particles and the baking soda from our device for further use. The porous filter absorbs the carbon particles which later can be extracted from the filter and the filter can be reused in the device. To extract the carbon we just have to bang the filter on a hard surface and the carbon stored in the filter will just fall off. Then we can reattach the porous filter on the device again.
Figure 3.7 below shows a picture of the device and the container after we did our first experiment.

After the collection of the carbon soot, we start to focus on the absorption of carbon dioxide. Carbon dioxide with washing soda turns into baking soda. We can identify baking soda by measuring its pH level which is significantly lower than the washing soda. We can also identify it once the solution is cooled off we can see a crystal base on the surface of the solution which indicates baking soda has been formed. Carbon soot and baking soda both can be used in various purposes of our life.

Figure 3.6: Remaining Things in the Container

Chapter 4

Result and Analysis

As mentioned in the previous section we used a gas sensor named MQ-135 and programmed it detect carbon dioxide in the atmosphere to map our environment continuously. It is the first phase of our project. For the sake of accuracy we took different sets of data at different times in different situation. After the detection of the gases our second phase is capture and collection of solid carbon particle in the emission. Last but not the least the third phase is absorption of carbon dioxide and the collection of baking soda as a by-product.

4.1 Data Collection Analysis

To collect the data from the environment we used Bluetooth terminal app from a smartphone and then connected it with our MQ 135 sensor model. Via the Blue- tooth module it transmitted data to the Bluetooth terminal app in the smartphone. The data were saved in the smartphone memory and later we collected it to ana- lyze the data. Here a series of screenshot from the app to make this process more understandable.

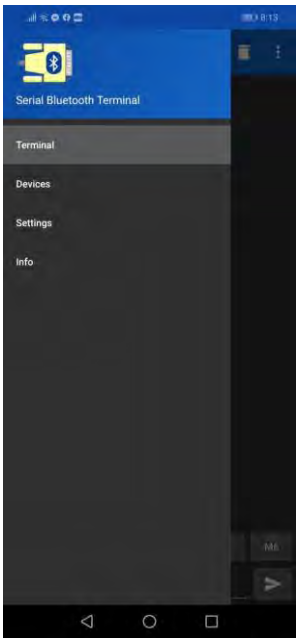


Figure 4.1: Interface of the App

Figure 4.1 shows the interface of the app. The Terminal panel shows the data that we are supposed to receive. And the Device panel shows the Bluetooth device that we are connected with.

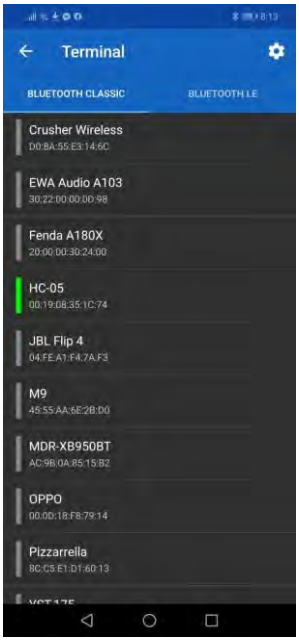


Figure 4.2: Bluetooth Panel of the App

Figure 4.2 displays the Bluetooth panel. As we can see in the picture, the green highlight, which shows HC-05, represents our Bluetooth module.

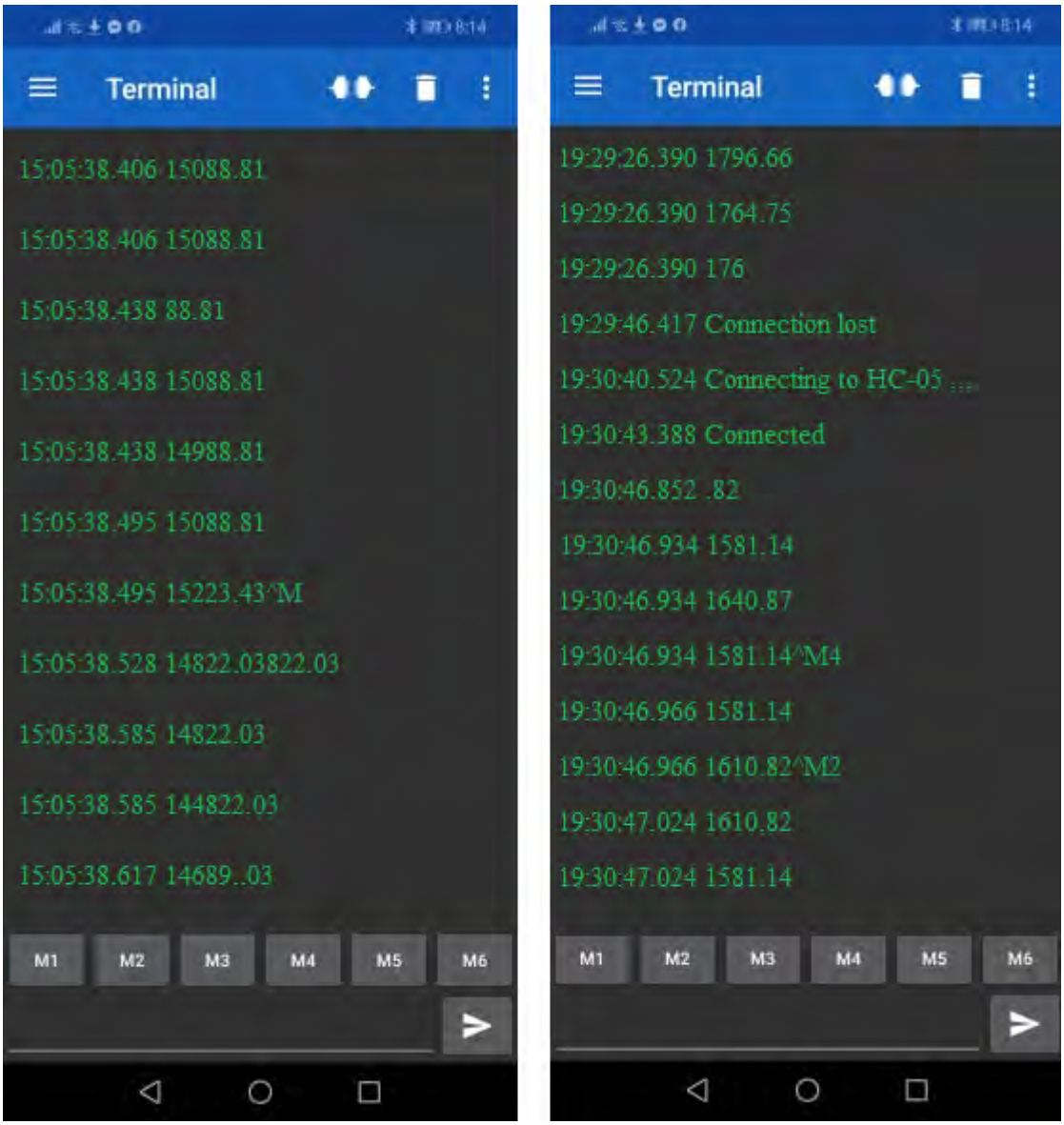


Figure 4.3: Terminal Interface of the App

Figure 4.3 shows the Terminal interface at different times. The Terminal Interface displays the data readings that represent the CO2 level detected in the atmosphere each second.

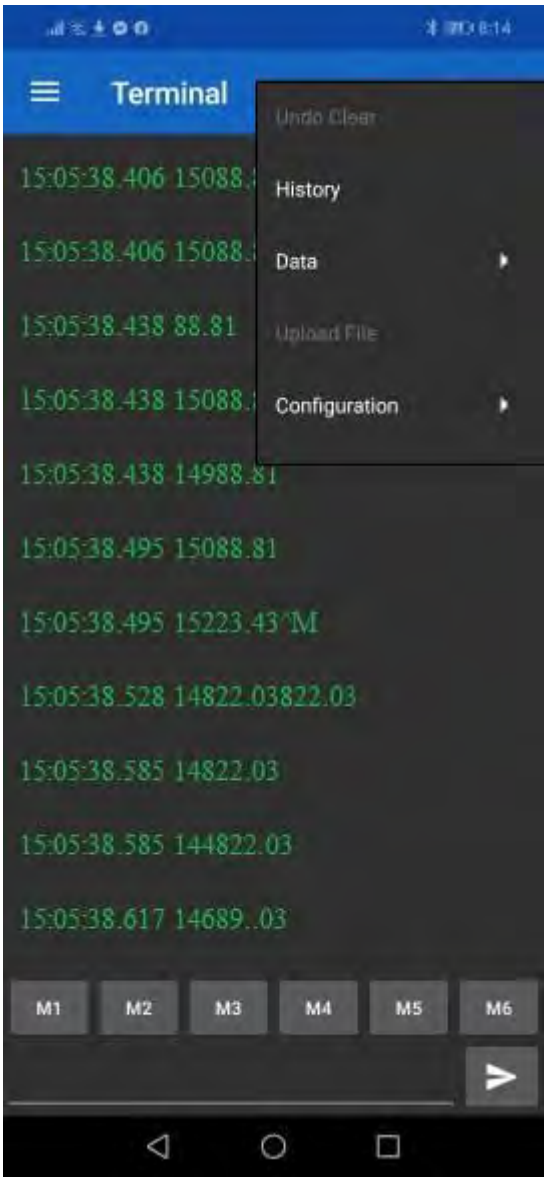


Figure 4.4: How We Saved the Data

Figure 4.4 shows how we saved the data. We have to click the Top right corner button.

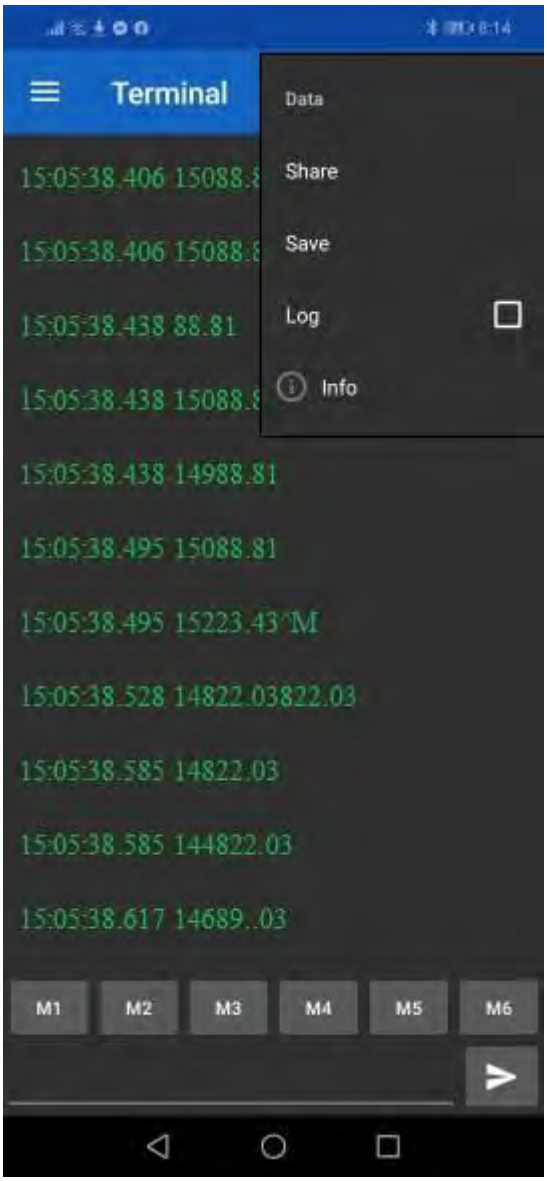


Figure 4.5: Save and Share Options

Figure 4.5 shows the Save and Share options. Under the data tab, we click on the Save and Share option to save the data in the phone memory. It can also be shared virtually via email, facebook, messenger, etc.

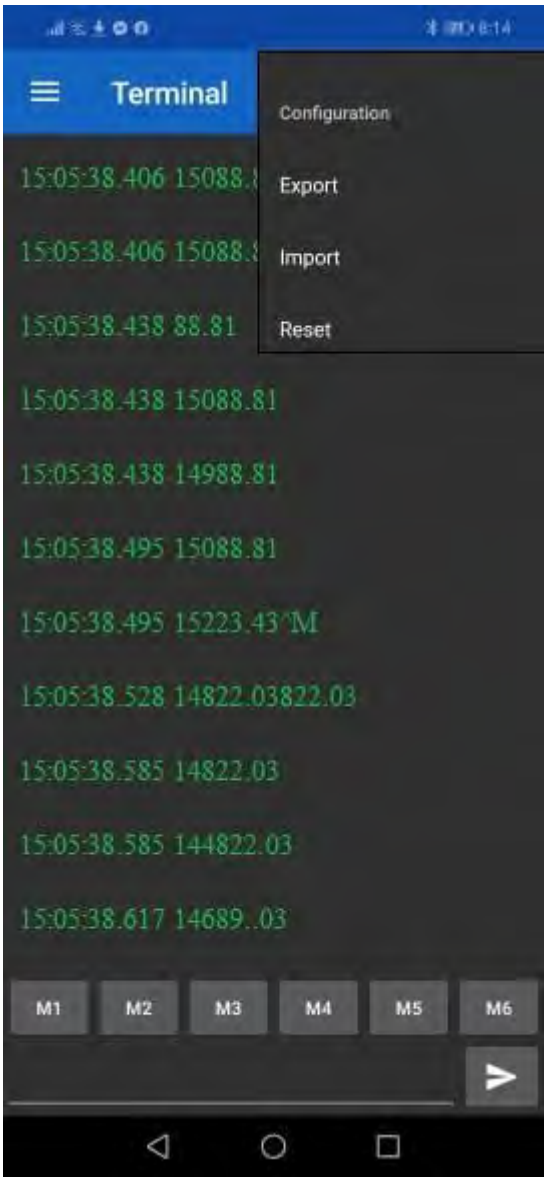


Figure 4.6: Export and Import Option

In Figure 4.6, we can see that under the Configuration tab, clicking on Export or Import can do their respective importing or exporting via Bluetooth or Internet.

Figure 4.7: When Cannot Be Connected

Sometimes, we faced difficulties when our interface failed to establish connections. Figure 4.7 shows what is displayed when it fails toconnect

.

After the establishment of the data collection process we decided to collect four sets

Time (hr:min:sec)	Carbon dioxide Level (PPM)
10:01:26.390	951.43
10:01:26.390	951.43
10:01:26.390	1016.16
10:01:46.417	1038.36
10:02:40.524	99.16
10:02:43.388	1016
10:02:46.852	972.72
10:02:46.934	994.27

Table 4.1: Some of the Readings on a Morning, Working Day (PPM)

of data, with each set being based on different time and situation to reach maxi- mum accuracy of our case. Varieties in time and situation produced different types of readings. We have produced a graph from each data set that represents different levels of carbon dioxide in the atmosphere.

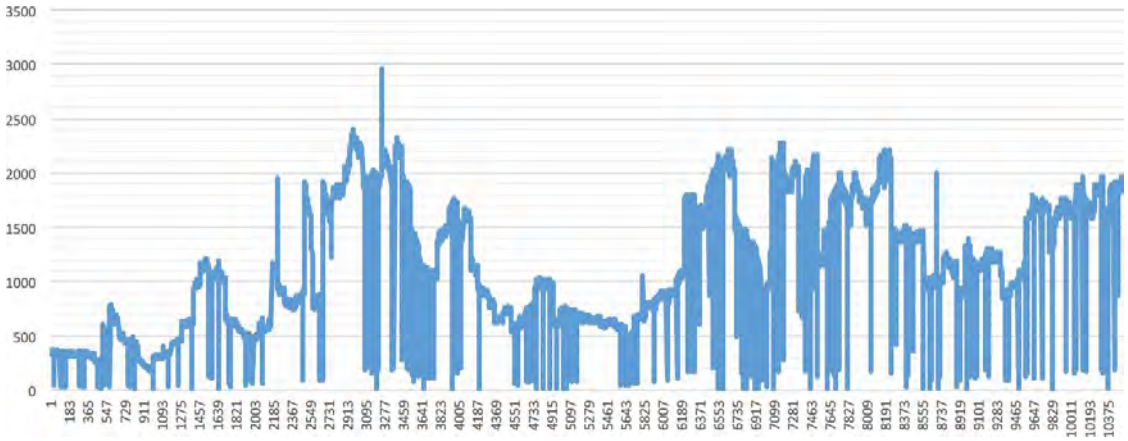


Figure 4.8: Readings in the Morning on a Working Day with Heavy Traffic

Figure 4.8 represents the readings that were taken on Sunday during 10:00 am to 10:30 am on the route of Mohakhali to Panthapath. As it was a working day, there were a lot of traffic on the road. From the graph, we can see that the highest point reaches up to 3000 PPM when we were crossing Farmgate, the busiest place on this

route.

Comparing to this data set we can see that in the following graph the carbon dioxide level was much lower than the previous one. We took the reading on the same route at the same time on a weekend and we can see that the highest point is between 1800-2000 PPM because the number of vehicles was much lower than theworking day. Figure 4.9 shows those readings below.

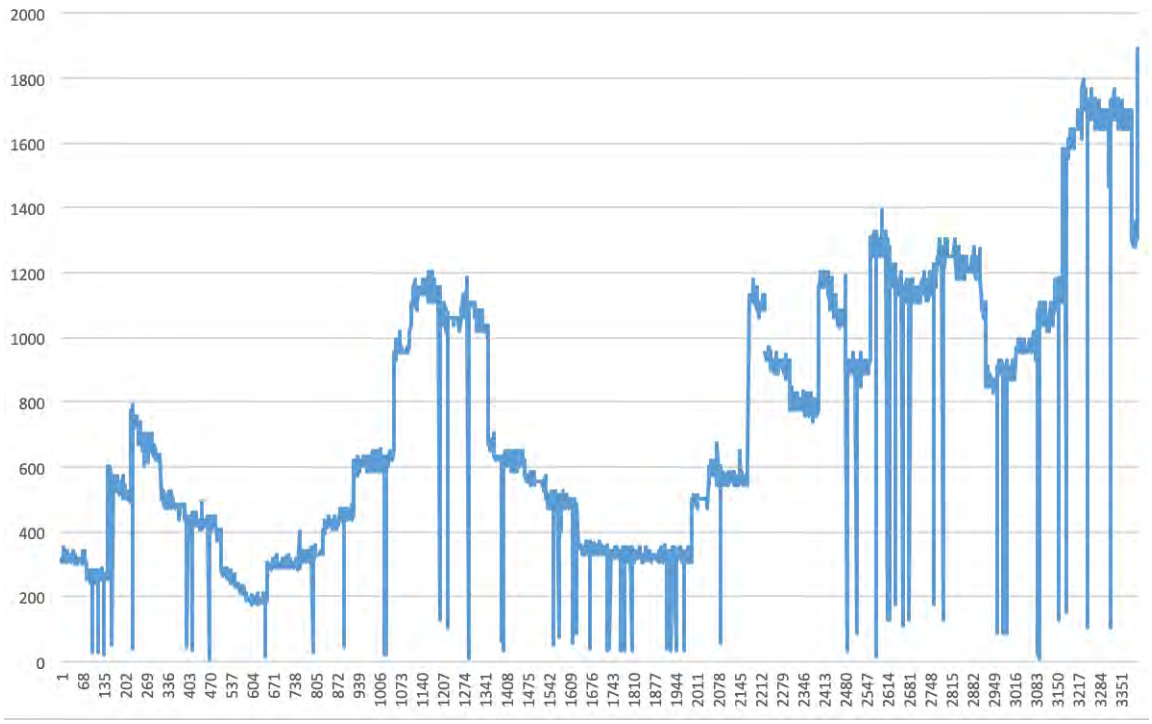


Figure 4.9: Readings in the Morning on a Weekend with Low Traffic

We took two more readings during day and night in Bashundhara Residential Area where the number of vehicles that produces carbon dioxide is close to null but still there was a huge fluctuation between these two data set because of photosynthesis and plants respiratory system.

Time (hr:min:sec)	Carbon dioxide Level (PPM)
10:06:46.934	351.3
10:06:46.934	329.74
10:06:46.966	351.32
10:06:46.966	340.44
10:07:40.524	351.3
10:07:47.024	340.41
10:07:47.024	362.41
10:07:47.024	351.3

Table 4.2: Some of the Readings on a Morning, Weekend (PPM)

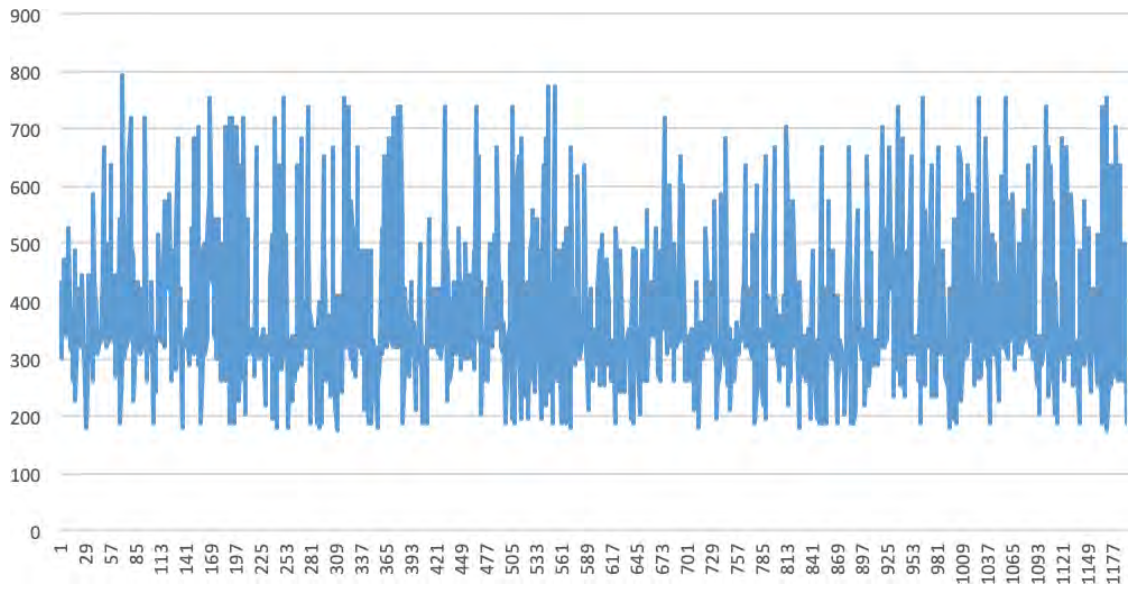


Figure 4.10: Readings during Afternoon with Very Little Traffic

Figure 4.10 shows the data set was taken in Bashundhara R/A between 12- 12:30 pm and that time there were a few cars and mostly rickshaws around. That is why the carbon dioxide level is much lower than the previous data we collected. Here we can see that the carbon dioxide level varies between 200 to 800 PPM roughly.

On the other hand in the same place at night with even less traffic the level is much higher than this fluctuating between 1000 to 1200 PPM represented in the following

Time (hr:min:sec)	Carbon dioxide Level (PPM)
12:03:19.035	299.05
12:03:19.035	319.23
12:03:19.035	421.43
12:03:19.099	319.29
12:03:19.124	279.66
12:03:19.124	309.06
12:03:19.174	299.05
12:03:19.174	542.542

Table 4.3: Some of the Readings on an Afternoon (PPM)

graph. This happened because the residential area has higher number of trees than the busy routes in Dhaka and trees do not perform photosynthesis process at night which requires carbon dioxide and light to perform. Moreover, at night plants res- piratory system emits carbon dioxide causing a greater amount of carbon dioxide in the atmosphere. Figure 4.11 shows the data set for those conditions.

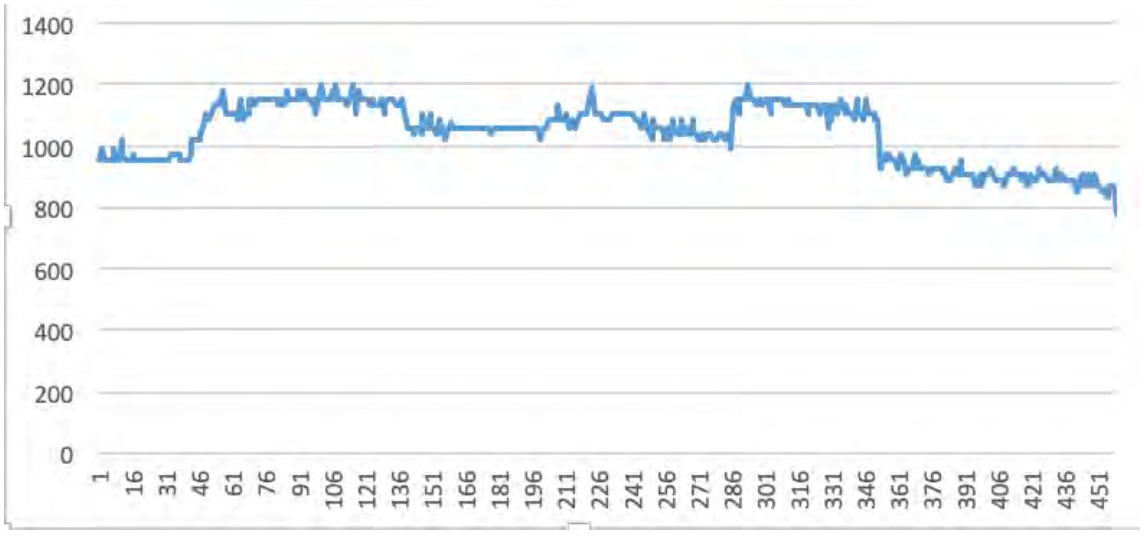


Figure 4.11: Readings at Night with Very Little Traffic

One main reason for the excessive amount of carbon dioxide present in the atmo-

Time (hr:min:sec)	Carbon dioxide Level (PPM)
19:12:57.202	1130.35
19:12:57.202	1106
19:12:57.202	1106.87
19:12:57.202	972.7
19:12:57.226	930
19:12:57.251	909.809
19:12:57.278	889.48
19:12:57.278	909.82

Table 4.4: Some of the Readings at Night (PPM)

sphere is the use of catalytic converter in the automobiles. Almost all the modern vehicles motorcycles or cars use catalytic converter to reduce the pollution in the atmosphere [8]. From the burning of fossil fuel other than carbon dioxide many other gases are released in the atmosphere. Among them carbon mono oxide is un- doubtedly very dangerous and lethal for any living creature. So the use of catalytic converter stops carbon mono oxide from entering the atmosphere. In the catalytic converter there is a phase called oxidation phase where the emitted gases who have a single particle of oxygen e.g. CO or NO are oxidized and become carbon dioxide or nitrogen dioxide [7]. The system is in use because carbon dioxide is not directly lethal towards our health however, it affects the bigger picture very badly. So we can see how the automobile around the world can contribute in the rise of carbon dioxide in the atmosphere which is a major reason behind greenhouse effect.

So after collecting all these data set our next step is to introduce a device that will effectively reduce carbon and carbon dioxide in the atmosphere by blocking carbon and carbon dioxide from the automobile emissions and prevent from entering the atmosphere as much as possible. The device we plan to make will be fitted on the tailpipe of the vehicle.

4.2 Purification of Pollution and Results

For the second phase of this project, first take a look at the last chapter of our paper where is a figure where the whole device is shown. From there we can see that after the air enters the vacuum cleaner first the emission goes through the porous filter where the unburnt solid carbon particles are absorbed. The porous filter we have in our device has a diameter of 70 mm diameter and can capture up to 30-40 mg of solid carbon which can later be extracted from the filter and it can be used to make ink. The filter also is reusable after the extraction.

For the third phase, to absorb the carbon dioxide in the emission, we used a 160mm long steel container with a diameter of 100mm on the top and 125mm in the bottom. Here we keep a solution of washing soda and water. The reaction of this phase is given below.

$$Na_2CO_3(aq) + CO_2(g) + H_2O(l) \rightleftharpoons 2NaHCO_3(g) \tag{4.1}$$

Figure 4.12 shows some pictures of the baking soda that we made from the experi- ments. We had to cool of the solution in order to get the baking soda. The solution first looked very white however after it cooled of we got baking soda crystals.

Figure 4.12: Steps to Make Baking Soda

According to the equation we can see with 1 mole of washing soda, 1 mole of carbon dioxide and 1 mole of water we should get 2 mole of baking soda. Just to clarify, the atomic mass of the whole equation is described below.

We know, Atomic Mass of Na = 23, C = 12, O =16, H =1 So, Atomic Mass of Washing Soda = 23*2+12+16*3= 106 Atomic Mass of Carbon Dioxide =44

Atomic Mass of Water = 18

Atomic Mass of Baking Soda = 2*(23+1+12+16*3) = 168

So here, we can see our raw material is washing soda, water and the carbon dioxide emission from the automobile. And our by product is baking soda.

Therefore, for 1 mole of washing soda we are supposed to get 2 mole of baking soda. In other words we are supposed to get 168 gm of baking soda from 106gm of washing soda. However, these values are strictly theoretical and almost impossible to achieve 100% accuracy in this project. Because with only 18gm of water with 106 gm of washing soda we can hardly form any solution through which the emis-

sion can pass. Still we performed multiple experiments through which in the end we reached an accuracy that makes this experiment not only valid but also very feasible.

At first we took 200gm of washing soda with 400gm of water to form a 600 gm of solution. During the experiment because of the splash we lost 300gm of solution and also 100 gm of the solution was remaining after a 30 minute experiment. In the end we retrieved 50gm of baking soda.

Second we took 300gm of washing soda with 300gm of water to form a 600 gm of solution. During the experiment because of the splash we lost 150gm of solution and also 120 gm of the solution was remaining after a 30 minute experiment. In the end we retrieved 70gm of baking soda.

Third time we took 200gm of washing soda with 200gm of water to form a 400 gm of solution. During the experiment because of the splash we lost 120gm of solution and also 70 gm of the solution was remaining after a 30 minute experiment. In the end we retrieved 60gm of baking soda.

Fourth and final we took 100gm of washing soda with 100gm of water to form a 200 gm of solution. During the experiment because of the splash we lost 20gm of solution and also 30 gm of the solution was remaining after a 30 minute experiment. In the end we retrieved 80gm of baking soda.

4.3 Accuracy and Analysis

So the calculation of the yield values for these results are given below. The equation to find yield value:

$$Yield = \frac{gotamount}{expectedamount} * 100$$

We are supposed to get 168gm of baking soda from 106gm of washing soda. So, from 200gm of washing soda we are supposed to get 316gm of washing soda theoretically.

Exp No.	Na2CO3 (gm)	H2O (gm)	Total Solu-tion (gm)	Total Waste (gm)	Expected Amount of NaHCO3(gm)	Got Amount of NaHCO3 (gm)	Yield
1	200	400	600	400	316	50	15%
2	300	300	600	270	475	70	14%
3	200	200	400	170	316	60	19%
4	100	100	200	50	158	80	50%

Table 4.5: Table for Percentage of Yield

However in the experiment we got 50 gm.

Therefore, the yield valuesare:

Yield1=(50/316)*100=15%

Yield2=(70/475)*100=14%

Yield3=(60/316)*100=19%

Yield4=(80/158)*100=50%

So here we can see from the first experiment to the fourth we could reach accuracy of50% from accuracy of 15%. So in the final product which is our goal as well in a more compact device we believe we can achieve even more accuracy on this project.

4.4 Identification

To identify and justify the chemical product that we have produced as baking soda we did a simple test chemical to clarify. We arranged a reaction between our product and hydrochloric acid. After that we got sodium chloride, carbon dioxide and water. The carbon dioxide was gaseous and made bubble in the experiment. The rest of the solution achieved a neutral level of pH level which is 7 whereas the pH level of baking soda is 8.3. So from the chemical components we found we can identify our product to be sodium bi carbonate also known as baking soda. Here is the chemical

Experiment No.	Purity	Average Purity
1	89%	90.25%
2	91%	
3	91%	
4	90%	

Table 4.6: Table for Average Purity

reaction that helped us identify it.

$$NaHCO_3)(aq)+HCL(aq) \rightharpoonup \quad NaCl(aq)+CO_2(g)+H_2O(l) \tag{4.2}$$

4.5 Titration Test

For titration test we followed the same formula as before. For this we took 3 gm of baking soda from each of our experiment and titrated with standard $0.1 mol/dm^3$ of HCl. We used methyl orange as an indicator in this process. So when the pH level drops to neutral 7 it changes color to pure orange. From that we can be confirmed about the purity of the product that we have produced. If the pH level is not 7 then it would not change color to orange. It would either be a bit yellow or red. Pure orange color indicates the best result we were expecting to achieve. Here is a chart of the purity level from each of our four experiment.

So if we take our last experiment in consideration we can see we got 80 gm of product or baking soda. And if it has 90% purity then we have generated 80*90% or 72 gm of pure baking soda from 100gm of washing soda and pollution from a motorcycle or carbon dioxide emission.

Chapter 5

Goal and Business Model

In the previous chapter of this project we have seen that with the device that we have introduced we can achieve almost 50% accuracy from the theoretical point of view. And in the beginning we could achieve only 15%. So with time and effort we managed to pull out the maximum result we can achieve in this limited amount of time. And we had to do this experiment on motorcycles or cars when they are standing still. However our goal is to build such a device which can be fitted on the automobile exhaust pipe all the time and this model will be more compact so hope achieve even more accuracy. A demo of our vision of the end product will be discussed later.

This device would be attach to the vehicle all the time and we will develop the device in such a way that only the filtration chamber would be replaceable whenever the filter is fully used. With the help of the pH meter installed in the device the user or any other person can identify if the filter is fully used or not because on a screen on the device it would be visible digitally. Moreover, the user can also be notified via an app that we are going to develop. As the pH level would drop over the use of the filter the user can be notified a significant amount of time before it runs out. Also in this app we are planning to show the user how much pollution they are blocking by using our device. In this model we can see that there is a Y shaped pipe in the front of the device where a very few amount of unfiltered emission would pass. We have put this there as a contingency plan. Anyhow if our device is not working or blocked, there is this way from where the emission can pass. So that the user can run their vehicle without any worries till they get help for the device.

A very significant part of this project is the continuous mapping of the environment through which we can be notified whenever there is a rise of carbon dioxide in the atmosphere than the usual. We are planning to use cloud computing for this mon- itoring system. We are going to plant these sensors on specific vehicles around the place or city. By doing this we are going to get multiple readings from around the city at real time. As our goal is to reduce air pollution we can be notified if there is excessive amount of pollution in a particular area and can take necessary steps towards the causes before it get worse.

We hope that every vehicle which uses fossil fuel would use our device because our plan is to make the environment better and at the same time make the customer happy. As we have mentioned earlier the filtration chamber of the device would be collected from our customers from which we will extract the byproducts, baking soda and the carbon soot. And this collection will happen in the petrol pump or gas pump where the automobiles like motorcycles, buses, trucks, cars visit on a regular basis to refuel. Our plan is to add a section in the app where a counter would be install to count each container they have provided us. On as estimation every bike refuels in every second or third day. So whenever they go to the petrol pump to refuel the container on our device would be checked and if it is fully used it will be replaced instantly and a new fresh one would be attached. And as previously discussed we would also introduce an app where the container they are returning would be counted. However if they do not have that app they would be provided with simple coupons which they can redeem later to get free fuel for their automo- bile. Calculating our profit we will decide how much fuel they would be provided with for how many coupons. However, theoretically we can do an estimate. Ac- cording to Bangladesh road and transport authority 469888 motorcycles have been registered in Dhaka till April 2018 and 1115654 motor vehicles in total [15]. As we tested our device mainly on motorcycles let's do an estimate on that only for now. In our device the porous filter that we use is reusable. After every extraction of the carbon soot it can be reattached in the container. On the other hand the market price of baking soda is double of the market price of washing soda right now. So basically our raw materials cost half the price of the byproducts that we are getting. According to our last result of the experiment where we achieved 50% accuracy, we

used 100gm of washing soda which market price is around 10 taka and from that we were able to produce 80gm of baking soda which market price should be around 16 taka. So on the raw material we can make a profit of 6 taka per unit. So if we take into consideration even half of the total number of motorcycles running around in this city which is around 200000 we should be making around 1200000 taka per week even if they return the used container once a week. And this number is just based on the baking soda that we are getting. We are also making ink from our device. And as our ultimate goal is to contain air pollution only blocking off carbon and carbon dioxide is not enough. The increasing of oxygen is also necessary. So we are planning to plant a tree in the city for every 100 liter ink we make. In this way we can reach the optimum state of the air very quickly. The numbers we have showed above was from just half of the motorcycles running in Dhaka city. We should keep in mind that buses and trucks also deals heavy damage to the air and most the public vehicles are very prominent source of air pollution as they have faulty engines. So our goal is to reduce air pollution by implementing our device on as many motor vehicle as possible. We did this experiment over motorcycles and cars only. However the same mechanism can be used to develop devices of different sizes corresponding to the fuel consumption of a particular automobile system. If we succeed in achieving our goal not only we can reduce air pollution on a very sig- nificant level but also make the general citizen aware and sincere about the gravity of the global problem called air pollution as every sincere citizen would be able to participate in controlling the pollution. Right now the general citizen do not even recognize the extreme problem we have in our hand. Moreover, we could create new job opportunities by maintaining this whole process of controlling the pollution and with the continuous monitoring of the atmosphere we can be ready to handle any kind of air pollution that occur.

We also want to use our device as a vehicle health checker. There are various kinds of particles responsible to degrade the quality of air. These particles are divided into few categories according to their size such as 1 PM, 2.5 PM, 10 PM, etc. Here 1 PM means this type of particles can have diameter up to 1 micron. Among them the most harmful category is 2.5 PM as it is very small in size and also produced at a much higher rate by any machine run by fossil fuel. The black smoke coming out of

vehicle falls under this category [1]. It can be measured using the Particulate Matter Sensor SPS30 which can not only detect 2.5 PM but also 1 PM, 4PM and 10 PM particles [2]. This can be used to monitor vehicle health as a particular vehicle is supposed to produce a specific amount of black smoke in healthy condition. Figure
5.1 shows the abundance of 2.5 PM solid particles in the air.

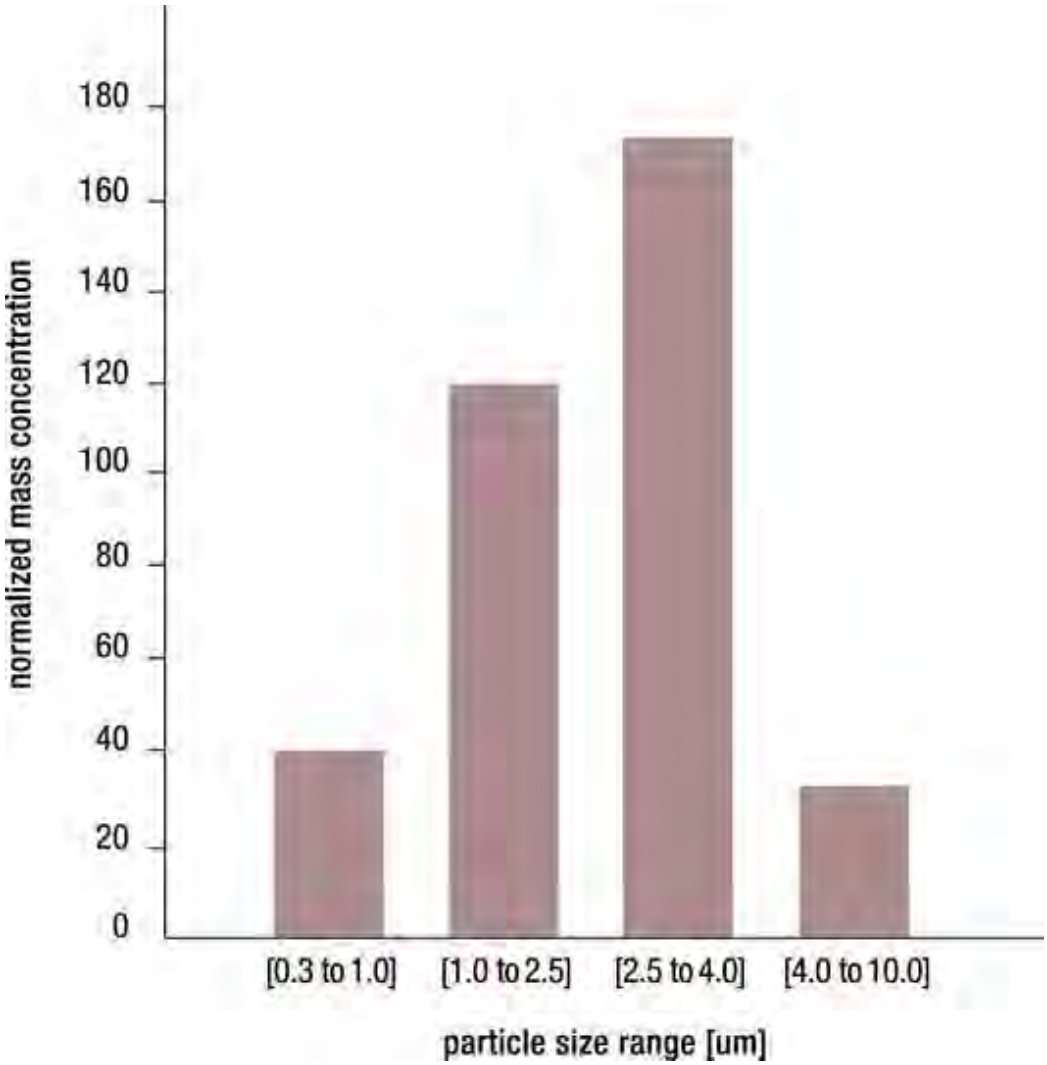


Figure 5.1: Abundance of Solid Particles in Air

With all our goals in mind we have made a design for our device. We really believe that it can fulfill all our goals while being affordable at the same time. Figure 5.2 shows the design given below.

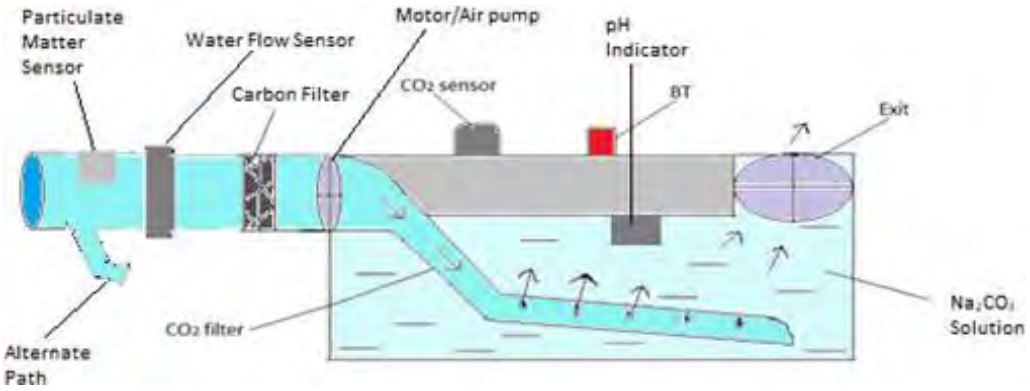


Figure 5.2: Design of Our Device

Here, the device uses the two filters as the current model with some additional sen- sors and more robust design. The particulate sensor detects solid carbon particle level which can let us know if a vehicle has faulty engine. This can save a big portion of our filters' effectiveness if we can act before it overwhelm our filters with solid carbons. In case the particles block our porous filter entirely the flow sensor can detect it instantly and the alternate path can be used instead of the filters till the filter is switched. The pH indicator can do the same work for carbon dioxide as the flow sensor and it can let us know when the whole solution is used in process.

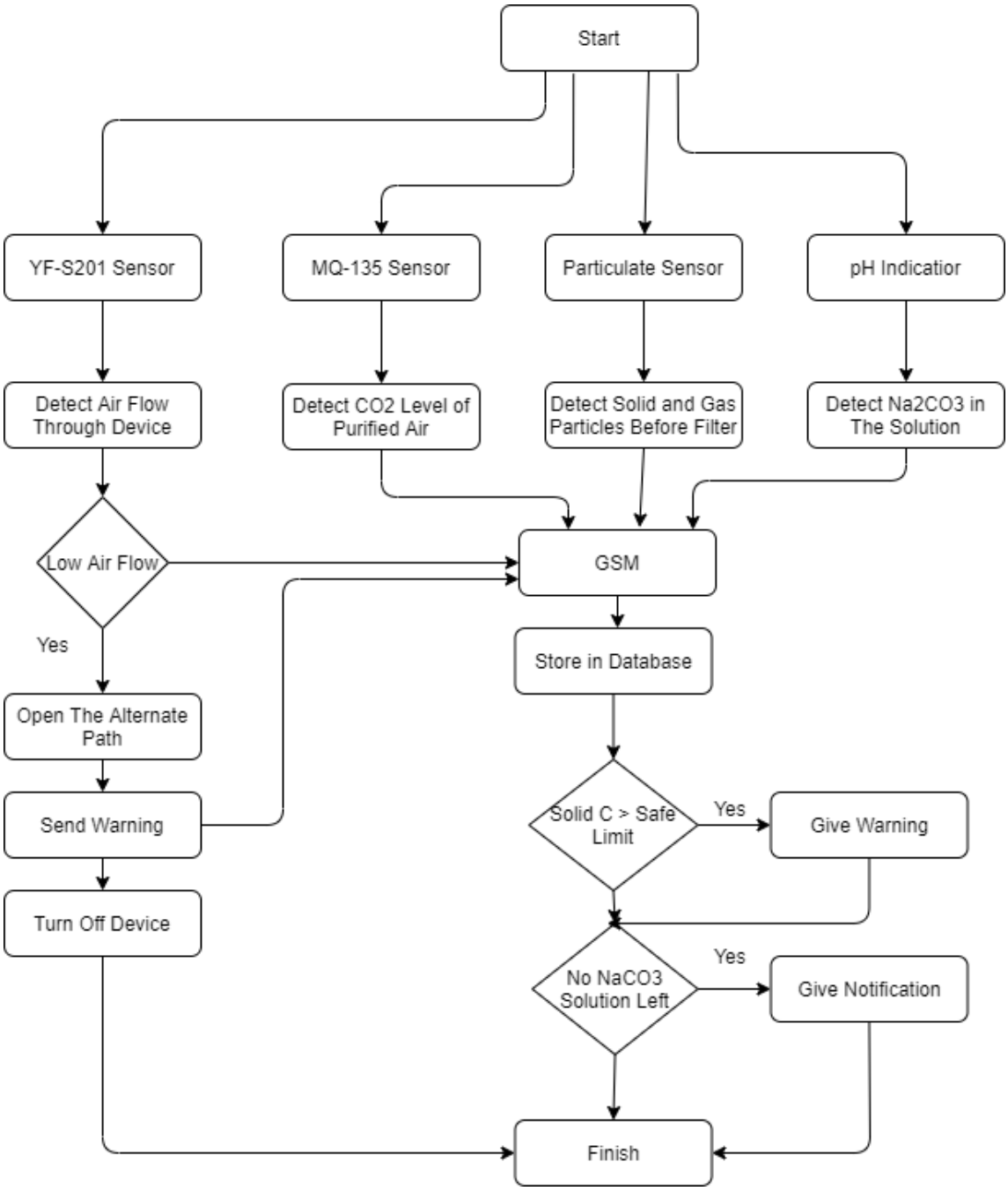


Figure 5.3: Flowchart of How the Model Works

Figure 5.3 can give a better understanding how the model is supposed to work. Here the MQ-135 gas sensor works like before but the YF-S201 works slightly differently. Instead of just giving warning when the air flow is low it sends signal to shut down the device and open an alternate path for the exhaust fumes. This is done locally and immediately without any external command. It ensures the longevity of our device and prevents the blockage from doing any damage to the engine. The pH sensor simple gives the notification whenever the concentration is almost used due

to reaction as the pH level decreases in the reaction. Finally the SPS-30 particulate sensor can detect the level of solid and gaseous carbon particles before entering the filter which can be used to monitor the health of the engine and to compare the data between before and after purification gas reading to measure the effectiveness. These data can be used to further improve the device to achieve more effectiveness.

Chapter 6

Purification System for Brick Kilns

Other than the emission from the automobile there is one other very significant source of pollution is the brick kilns [6]. The automobiles and the brick kilns emis- sion has on one thing in common that they both produce a lot of black smoke or the solid carbon particle. However the brick kilns produce this on a very large scale than the automobile. One other very prominent pollution of the brick kilns in the Sulfur dioxide which is a very harmful chemical for the atmosphere as it can be turned into sulfuric acid just by reacting with water and air. If this pollution is not controlled in time the excessive amount of the sulfur dioxide can cause acid rain and pollute and destroy rivers, crops and the human health nonetheless. However we are proposing a theoretical solution for now. As we have discussed before we can use the carbon soot for later use and also use the sulfur dioxide from the pollution to create sulfuric acid. The raw materials that we are going to need for this are only water and air. There are few stages of the model that we are proposing. Our most challenging task would be controlling the heat. The brick kilns produce up to 800-1100 degree Celsius. No if we put any structure over in it will be burned to the ground immediately. How- ever, the melting point of steel is around 1300-1500 degree Celsius. So with that we have come up with a solution that would include three stages as shown in Figure 6.1.

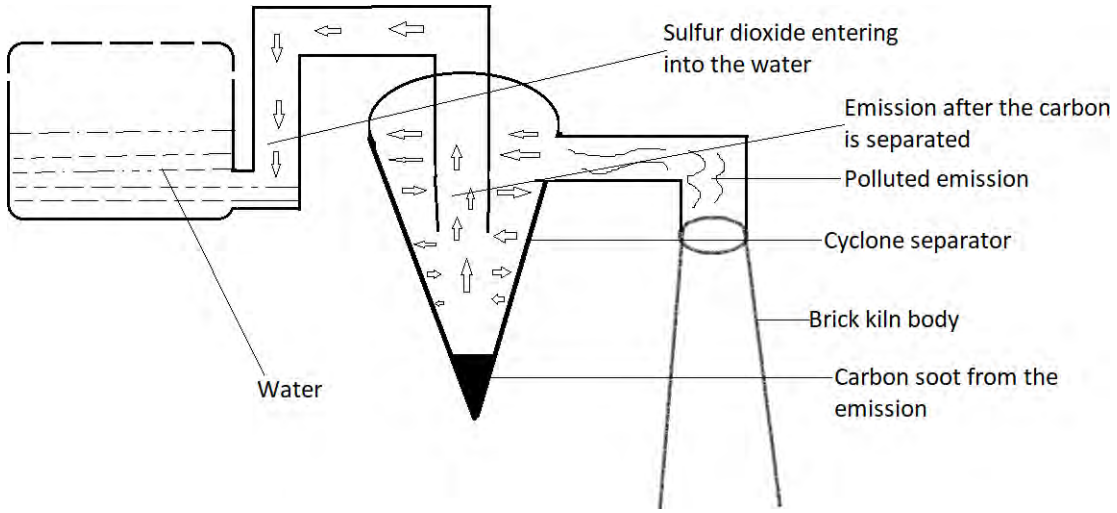


Figure 6.1: How the Solution is obtained

6.1 Capture and Control Phase

In this phase the emission from the brick kilns would be captured and channeled towards the next phase. But this task is very difficult to achieve. Though the melting point of steel is higher than the heat the system produces, we want install a heat ex-changer for this process. This could be a radiator like the ones used in the car engine in the combustion system or a regular heat ex-changer will do the work.

6.2 Separation Phase

Once the heat is controlled our main challenge is to separate the solid carbon particle from the rest of the gas emission. For this we are proposing to use cyclone separator. The shape of the cyclone separator is just like a cyclone. When the emission enters the separator on the top it enters with a specific amount of force. We can control the force by the shape of the entry point. The smaller it is the greater the force will

be. So we would have to measure an optimum size for the entry point which would create enough inertia for the emission and also does not create additional pressure for the system. After the emission enters the separator because of the principle of inertia the emission with the solid carbon particles move by the wall of the body and go downwards. When it reaches at the bottom of the separator the carbon particles are dropped and cannot go up anymore because of the gravity. However the lighter emission then or the carbon free emission uses centrifugal force to go up and through another tunnel it passes through the next stage of this process. The carbon that is in the bottom of the separator can be collected later via the valve at the bottom that we are going to install.

6.3 Reaction Phase

After the emission passes through the next we will simply run it through water. The top of this container would be closed to avoid any kind of accidents. However there will be holes to let the air in because air from the environment is a raw materials other than water. So when sulfur dioxide goes through water it turns into sulfurous acid first. Later when it comes in touch with the air it reacts with the oxygen of the air and turns into sulfuric acid. The two chemical reactions that are going to take place in this process are given below.

$$SO_2 + H_2O \rightarrow H_2SO_3 \tag{6.1}$$

In the first reaction, sulfur dioxide reacts with water to form sulfurous acid.

$$2H_2SO_3 + O_2 \rightarrow 2H_2SO_4 \tag{6.2}$$

In the next reaction, sulfurous acid reacts with oxygen to form sulfuric acid.
For the limitation of time and other obstacle we could not hold any practical ex- periment on this. So we are just proposing a theoretical model and plan for this. However, we would like to continue on this research because we believe this is a very prominent source of air pollution and at the same time a very promising way of creating industrial level sulfuric acid. Sulfuric acid without any doubt is a very

well-known and widely used acid around the world. A country's economy largely depends on the amount of sulfuric acid it has. So in the near future if we can make this project a success not only we can reduce a very huge amount of pollution in the air but also contribute to make a huge amount of usable sulfuric acid.

Chapter 7 Future

Work

We have to keep in mind that in this project we just worked with the major en- vironment pollutants that affect our environment on a larger scale than the other pollutants. However there are other pollutants nonetheless which maybe emitted to the environment in a negligible amount right now but they are still a threat towards our environment. As our plan focuses on the cleansing of the harmful matters from the air we would like to continue our research on various pollutants present in the atmosphere and figure out different possible ways to detect them before they get re- leased on a lethal amount and find our feasible ways to not only block them but also make useful products out of them which can later be used. Because of the limited amount of resources we had to think very critically in this project to come up with feasible ideas to fight the major air pollution. In this fight with air pollution in the future we would like to introduce renewable energy in our project so that we can generate the amount of energy we need to run a particular device which would have different types of filter inside to filter out any particular pollutants present in the air. With renewable energy we believe we can reach the peak of our vision where the air will just have healthy breathable components to preserve human health the way it is meant to be preserved.

Chapter 8

Conclusion

With more people being able to afford vehicles for transportation, we can assume that the side effects of vehicular exhausts is more extreme nowadays. Moreover, as more factories are being established nowadays, exhaust fumes from brick kilns are also on the rise. Since air pollution is a very crucial issue in Bangladesh, especially in Dhaka, we decided to reduce the effect of air pollution by dealing with at least two of the major sources of air pollution.

For our project, we researched various topics in order to see what is lacking in the previous works when it comes to dealing with pollution that comes from exhaust fumes. The other projects mostly dealt with the blocking of the carbon particles from fumes. But our intent is to prevent more components from reaching the environment, and in a more efficient manner. In order to reach our goal, we carefully searched for various types of sensors that are very beneficial when it came to detecting the harmful components in the exhaust fumes in order to block them. We studied and selected our sensors very carefully in order to see which ones were going to be the most effective as well as the most cost efficient.

With our thesis project not only the harmful effects by exhaust fumes will be greatly reduced, but there are other benefits as well. Since the harmful components from the fumes are being prevented from reaching the outer environment, we are also collecting them so that they can be used as resources for other greater purposes. These components which were initially harmful can be be used to create useful products like ink and baking soda. Since we have made our project at a rather reasonable price, we are sure that various people in Bangladesh will be able to buy

our project and help to contribute to the reduction of air pollution.

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