PDPM
Indian Institute of Information Technology Design and Manufacturing,
Jabalpur

Design Project Report

DS-302

Controlling Air Pollution Emission

Group B2-06

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April 18, 2018

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Abstract

In this report we will give you an overview of our design project Vyom with the specifications and rendered images of its CAD model explaining it's functionalities.

The report contains description of all the user needs, different concepts that we created in order to meet those user needs, the evaluation process that we followed to evaluate our concepts and techniques that we applied in order to choose our final concept. It also contains the descriptive explanation of our concept and how it will serve our need statement.

There are numerous diagrams and charts that explain the issue that we are tackling, our need statement, design and provide a better understanding of what Vyom is all about. We've used sketches and renders to make it easier to visualize the looks and functioning of our concepts and final design. We've included some facts from different sources in order to strengthen our points and provide a better insight into the issue.

After making final prototype of our product this report also includes the fabrication procedure that we followed to complete this project, it's testing report what makes Vyom and efficient product and a smart device to tackle the air pollution.

1 Introduction

With the rise in global warming and increasing pollution levels on metropolitan roads, it is becoming essential to find a viable alternative to reduce the pollution on the crowded roads.

Metros across the world bear the major brunt of environment pollution and Total Suspended Particulate (TSP) is 3 times the level WHO above annual average in in these cities which is having an adverse affect on the health of people and biodiversity nearby.

The Aim of this project was to create a product to lessen the pollution level on busy roads where the main criteria being it's cost and environment friendliness in terms of both efficiency and materials. This Report present design of six such forms, where initially we build the need statement, specified the product specification to come up with a single form upon evaluating them on benchmarked product.

Finally the most efficient product design is proposed with detailing of the process after product specification were screened with user requirement, need statement and effectiveness of the cost.

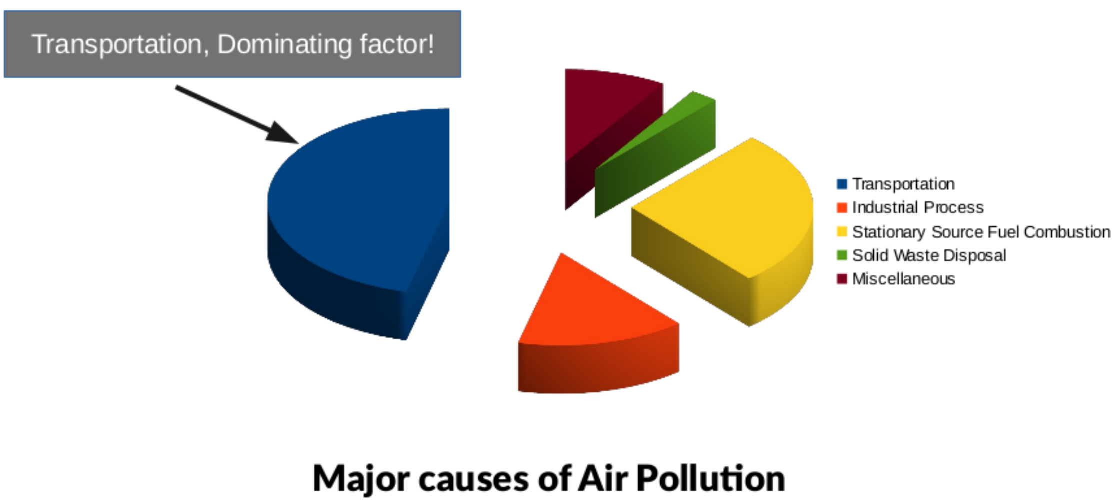


Figure 1: Major Causes of air pollution

2 Objective

The project aims towards reducing the amount of Particulate matter in the air around busy roads. Our desired product should be better than the existing solutions like anti-pollution mask, smog sucking bikes etc. and should provide better environment around busy roads. We expect our product to be able to reduce PM10 and PM2.5(particulate matter of 10 and 2.5 micron) levels on such roads significantly resulting in an environment that is pollution free and harmless to human life. The product should ensure and maintain clean air and provide safety to nearby biodiversity. On the whole, the product we aim to design should reduce concentration of particulate matter in the air around heavily crowded roads.

3 User and Literature Survey

3.1 User Survey

Due to the seriousness related to the issue, it is decided to do the user survey by observation and direct interviewing. The main asked were as follows,

Questionnaire

1. Do you face traffic daily?
2. Do you use open Vehicle like auto and bikes?
3. Do you face any problem due to air pollution?
4. Whether you faces health related problem due to pollution?
5. Is minimization of air pollution on roads a good solution?

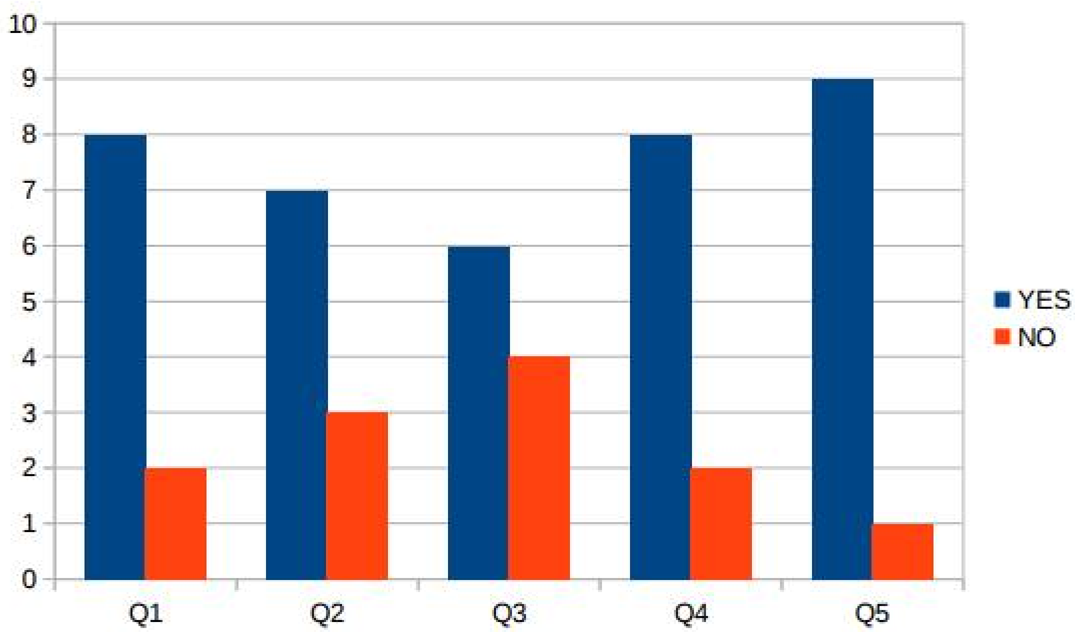


Figure 2: Responses of User survey through Bar Chart

Analysis of Data]

- Around 90% people accepted to minimize on-road air pollution as a good solution.
- 65-85% people accepted transportation as a major cause
- 80% people said that they are facing health related issues due to air pollution

3.2 Literature Survey

- Filtering Mask
  - Easily available and user friendly
  - No protection against skin and eye problems

Figure 3: Filtering Gas Mask

- Smog sucking Bikes(Proposed Solution)
  - For specific people owning the bikes
  - Purifies air while you are cycling

Figure 4: Smog Sucking Bikes

- Parasitic Robots (Theoretical Solution)
  - Absorbs pollution, to generate its own power

Figure 5: Parasitic Robots

4 Need Statement

To design a sustainable solution to the problem of air pollution on busy roads that is not user specific and is cheap and efficient.

4.1 Expectations

- Should tackle problems like tearing of eyes
- Energy-efficient
- Less noisy
- Not user specific
- Cost effective

5 Product Specification

5.1 Benchmarking

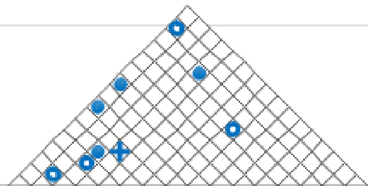
To get to know more details about specification of the product with some benchmarked products in this field. Gas Mask and smog sucking being the most prominent, we benchmarked specification with them.

	IMP	PLANNED		GAS MASK		SMOKE SUCKING BIKE	
		RATING	Wgt. Rating	RATING	Wgt. Rating	RATING	Wgt. Rating
Improve air Quailty	5	4	20	3	15	2	10
Tough Casting	3	4	12	2	6	4	12
Energy Efficient	4	4	16	5	20	5	20
Low Maintenance /Installation Cost	5	4	20	5	25	4	20
Need not to carry	5	5	25	1	5	1	5
Water proof	4	3	12	1	4	4	16
Less Noisy	3	4	12	5	15	4	12
Attractive	2	3	6	2	4	3	6
No Seasonal Effect	4	4	16	4	16	3	12
Low Production Cost	4	4	16	5	20	4	16
Low carbon Footprint	4	3	12	4	16	4	16
Uses Renewable Energy	3	5	15	4	12	5	15
Robust Design	4	4	16	2	8	2	8
Durable	5	4	20	1	5	2	10
SUM	55	55	218	44	171	47	178
AVG.			15.57		12.21		12.71

Figure 6: Benchmarking

5.2 Quality Function Deployment (QFD)

For our quality function deployment we gathered the engineering specifications that our product must have and mapped it with our customer requirements. We also benchmarked our product against existing product that dominates the market i.e the pollution gas mask.



Requirements	Customer Importance	Power Consumption	Impact Strength	Material Cost	Production Cost	Hydrophobic	Anti Corrosiveness	Recyclable	Average Working Time	Thermal exp.Coefficient	Filtering Time	System Bulkiness	Thermal Conductivity	Inlet/outlet air Velocity	Body Design	Air Filtering Technology	Heat Emission	Productin Market (Smog sucking Bikes)	Planned Product	Improvement ratio	Sales point	Importance	Relative weight
Improve air Quailty	5								9		9					9		2	4	2.0	1.5	12	0.110
Tough Casting	3		9	3														4	4	1.0	1.0	4	0.038
Energy Efficient	4	9																5	4	0.8	1.4	4.5	0.043
Low Maintenance /Installation Cost	5														3	3		4	4	1.0	1.0	4.0	0.038
Need not to carry	5																	1	5	5.0	1.5	37	0.355
Water proof	4				3	9									3			4	3	0.8	1.0	2.4	0.023
Less Noisy	3								1					9		3		4	4	1.0	1.0	4.0	0.038
Attractive	2														9			3	3	1.0	1.0	3.0	0.029
No Seasonal Effect	4					9	3			3			3					3	4	1.3	1.3	6.8	0.065
Low Production Cost	4			3	9							3						4	4	1.0	1.0	4.0	0.038
Low carbon Footprint	4	3						9								9	1	4	3	0.8	1.0	2.4	0.023
Uses Renewable Energy	3	9																5	5	1.0	1.2	6.0	0.057
Roboust Design	4														3			2	4	2.0	1.0	8.0	0.076
Durable	5			9												3		2	4	2.0	1.0	8.0	0.076
Absolute Importance		75	27	66	48	72	12	36	48	12	45	12	12	27	57	120	4						
Relative Importance		11	4	9.8	7.1	11	1.7	5.3	7.2	1.7	6.6	1.7	1.7	4	8.4	18	0.5						
Benchmarking			2	3	1			1	2		1	1				2							
Direction of Movement		↓	↑		↓			↑	↑		↑					↑							
Target Value			3	3	1			4	2		1	1				4							
Units		KW	N/m2						Hrs	1/C	Hrs		W/(m. K)	m/s			J/s						

Figure 7: Quality function Deployment

Specification of the product can be divided into two broad categories which are listed below.

5.3 Qualitative Specification

- **Seasons shouldn't effect it**
  As the product will be open to atmosphere, so it must not be affected by any particular season.

Figure 8: Different seasons

- **Tough Casting Material**
  Frequent accidents and other damages on roads can be catastrophic for the product so the material used must be tough.

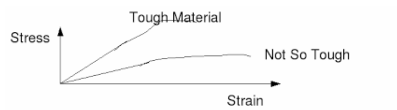


Figure 9: Stress vs Strain curve

- **Energy Efficient and Low Power Consuming**
  70% of energy still is being produced by non-renewable sources and that would be indirectly affecting the nature.

Figure 10: Power Grid

- **Maintenance and Installation Cost**
  As the product is being used in public domain so its maintenance cost must be low and to avoid unnecessary Traffic on roads.

Figure 11: Under Maintenance

- **Water Proof**
  Flooding of Roads in rainy season is a very common issue in many developing countries so the product must be water proof to protect it's electronic component.

Figure 12: Waterlogging

- **Less Noisy and attractive**

  It should produce the least possible Noise and should be aesthetically pleasing also. Noise pollution is a major concern for crowded roads as it is producing around 80dbA loudness on the busy with heavy traffic.

Figure 13: Noise pollution

5.4 Quantitative Specification

Specifications	Details
Power rating <50W	Per unit of system
Inlet air PM10 level >80	WHO standard 40
Outlet air PM10 level <80	
Net Width <0.75m	Width to maximize area coverage
Net Height <1.2 m	For better efficiency
Net Depth <0.5m	Maximum depth of divider
Height of Outlet >0.5m (above device)	Avoid mixing of clear air
Inlet air volume flow rate >1030 gal/hr	Expected outcome
Inlet air velocity 8.67-13.33 cm/min	

Table 1: Quantitative Specification.

6 Concepts

By examining our user needs we generated a few concept that deliver their requirements and can be possible solutions to the problem of air pollution. Details of those concepts is discussed below.

6.1 Underground pollution suction system

- Suction system along with the filtration system will be fitted under the roads.
- The polluted air inlet vents will come on the surface of the road or along the sides.
- The clean air outlet will be away from roads in order to avoid re-filtering.
- This will be a centralized system with a single filtering system for multiple polluted air inlet vents.

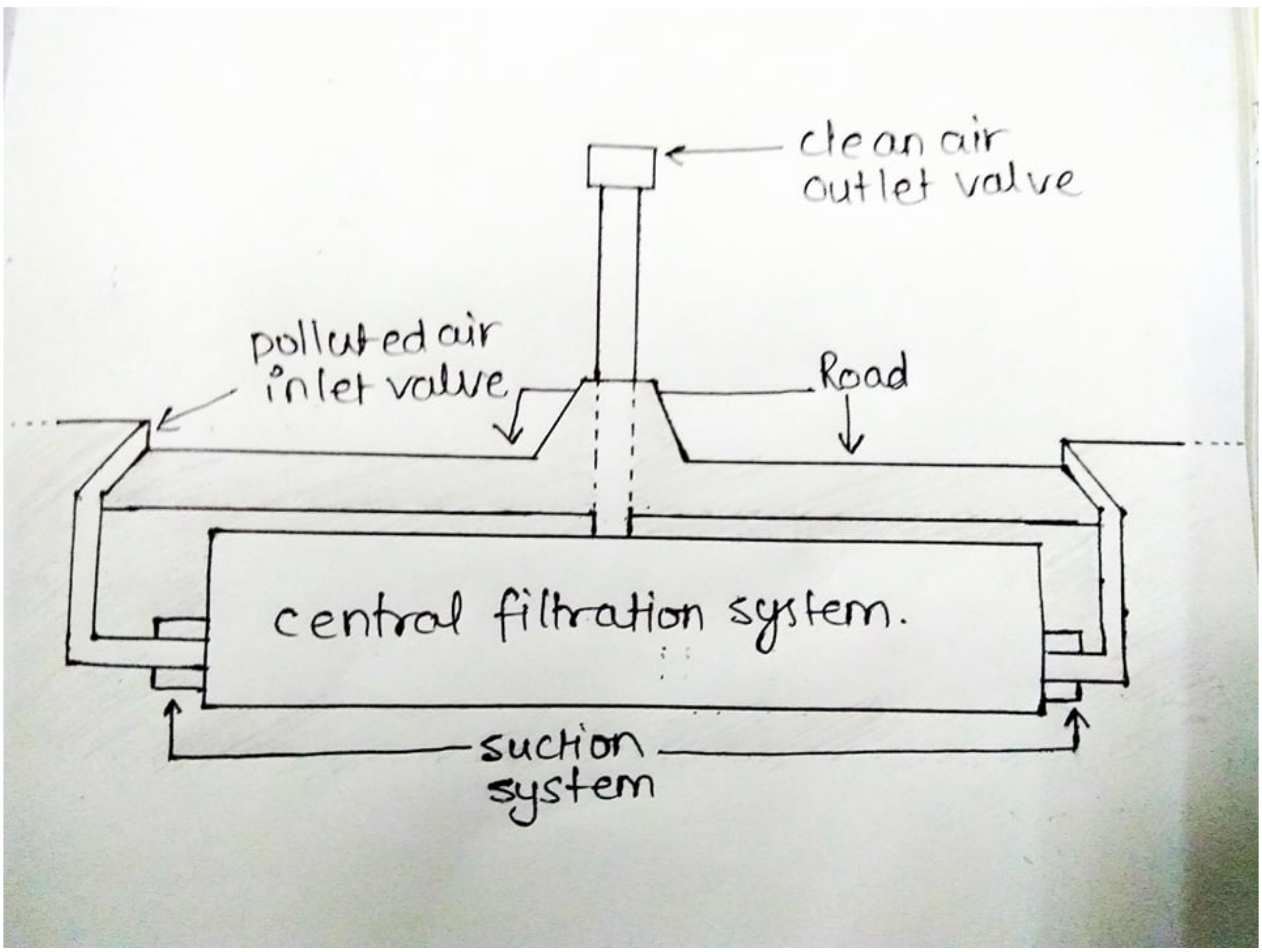


Figure 14: Underground suction system sketch

6.2 Overhead pollution Suction system

- Multiple overhead arches will serve as inlet vents for polluted air.
- There will be a centralized filtration system for all overhead inlet arches.
- The clean air outlet will be attached to the central filtration system.
- This is a centralized system where the filtration system will be placed somewhere near the roads.

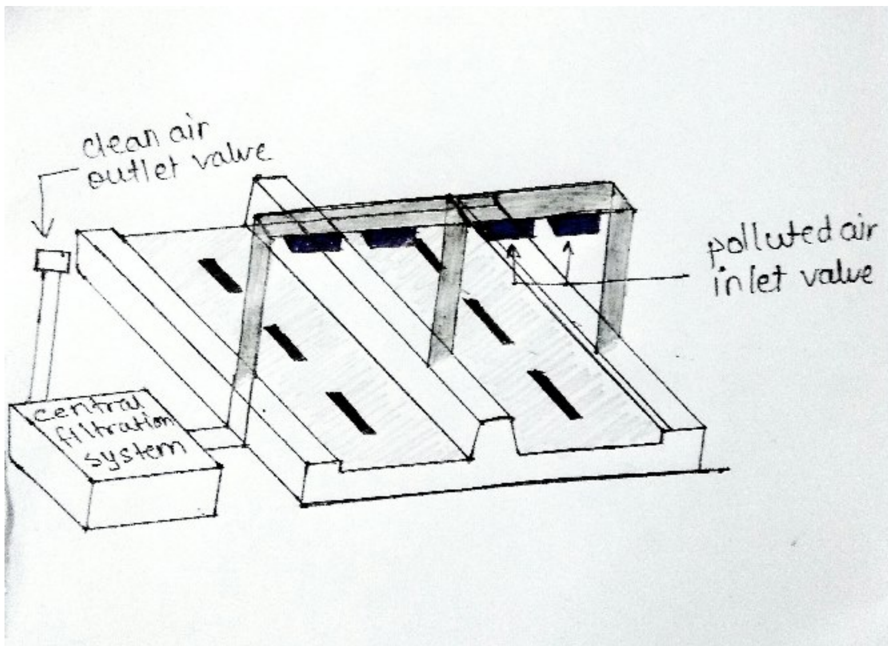


Figure 15: Overhead Pollution Suction System Sketch

6.3 Electrostatic precipitation system

- A set of inlets will pull the polluted air from the roads.
- An electrostatic precipitator will remove the suspended particulate matter from the polluted road.
- The outlet will grow out from the precipitator to release the purified air.

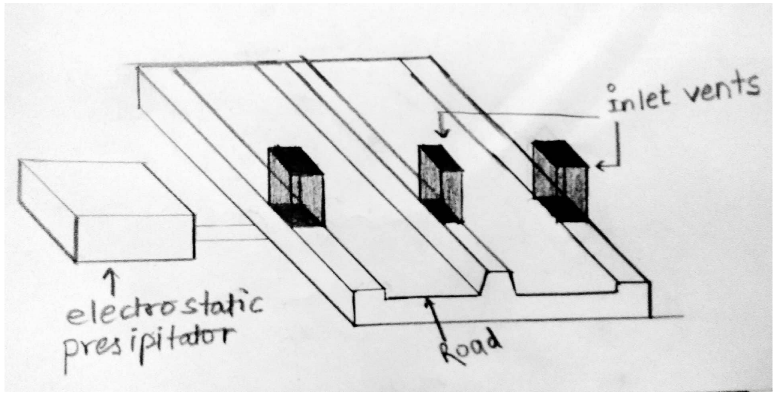


Figure 16: Electrostatic Precipitation system Sketch

6.4 Pole based pollution suction system

- A boxed structure holding the inlet, outlet and filtration system will be placed on any supporting pillar or pole.
- The whole filtration process will take place inside the boxed structure.
- Any particular road will hold a number of such structures with a central controller to synchronize them.

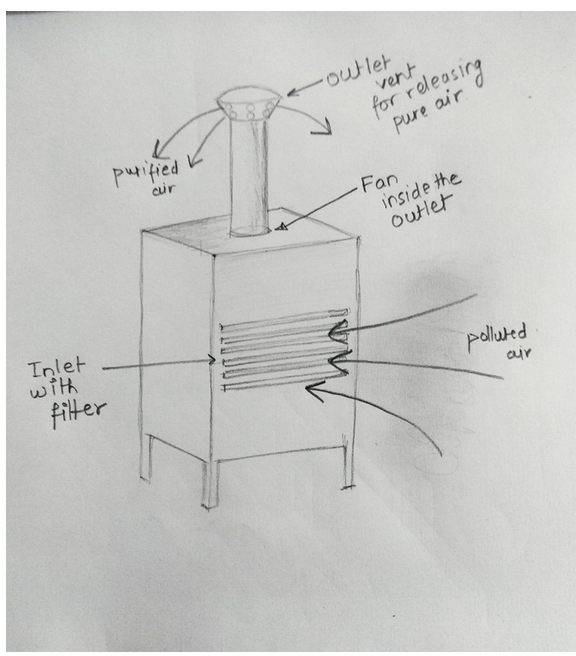


Figure 17: Pole Based suction System

6.5 Smog sucking vehicles

- A filtration system along with an inlet will be installed on the front of big vehicles like cars and buses
- The vehicle will suck the pollution, purify it, and release the purified air onto the surroundings.

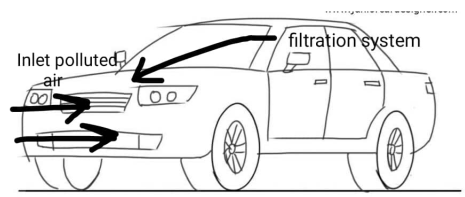


Figure 18: Smog Sucking Vehicles Sketch

6.6 Exhaust smoke purifier

- A filtration setup will be installed on the exhaust pipes of vehicles.
- The filtration system will purify the air and remove the excess particulate matter from the exhaust air.
- This will target the root cause of major road and city air pollution

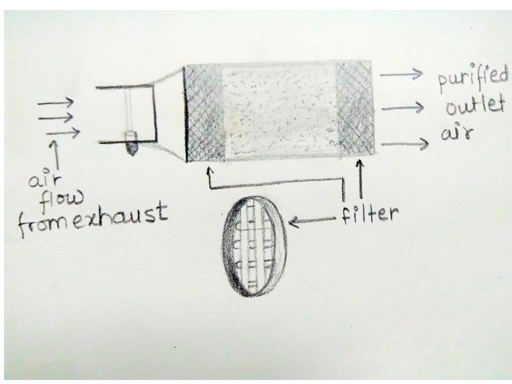


Figure 19: Exhaust smoke purifier Sketch

7 Concept Evaluation and Selection

Evaluation of concept against the user needs and the way they fulfilled there need. We visualized the scenarios that our product might face while functioning. We listed out pros and cons for each concept that we developed. We used techniques like Pugh's selection method to evaluate each concept.

7.1 Pugh Concept Selection Method

Those concepts which have positive score were considered in further iteration for pugh concepts selection.

concept#	Name
Concept1	Pole based polluton suction system
Concept2	Smog sucking vehicles
Concept3	Electrostatic precipitation system
Concept4	Exhaust smoke purifier
Concept5	Overhead pollution suction system
Concept6	Underground pollution suction system

Figure 20: Concepts

CRs \ Concept	Concept1	Concept2	Concept3	Concept4	Concept5	Concept6
Improve air Quailty	+	-	DATUM	-	+	-
Tough Casting	+	-		-	+	+
Energy Efficient	+	+		+	+	-
Low Maintenance /Installation Cost	+	+		+	-	-
Need not to carry	0	0		0	0	0
Water proof	+	+		+	0	+
Less Noisy	+	+		+	0	0
Attractive	0	+		+	0	0
No Seasonal Effect	0	0		0	0	-
Low Production Cost	+	+		+	0	0
Low carbon Footprint	+	+		-	0	-
Uses Renewable Energy	0	-		+	0	0
Roboust Design	0	-		-	-	-
Durable	+	-		-	0	-
Sum +	9	7		7	3	2
Sum -	0	5		5	2	7
Sum 0	5	2		2	9	5
Net Score	9	2	0	2	1	-5
Rank	1	2	4	2	3	5
continue	Y	Y	Y	Y	Y	N

Figure 21: Pugh selection based on Customer Requirements

ECs \ Concept	Concept1	Concept2	Concept3	Concept4	Concept5	Concept6
Power consumption	+	+		+	+	-
impact strength	+	-		-	+	+
material cost	+	+		+	-	-
production cost	+	+		+	-	-
Hydrophobic	0	-		-	+	+
Anti Corrosiveness	+	+	D	-	+	+
Recyclable	+	-		-	-	-
Average Working Time	0	-		-	0	0
Thermal exp.Coefficient	0	+	A	+	0	+
Filtering Time	+	+		+	0	0
System Bulkiness	+	+	T	+	0	-
Thermal Conductivity	0	+		+	0	+
Inlet/outlet air Velocity	0	-	U	-	-	-
Body Design	+	+		+	0	0
Air Filtering Technology	-	-	M	-	-	-
Heat Emission	+	+		-	0	0
Sum +	10	10		8	4	5
Sum -	1	6		8	5	7
Sum 0's	5	0		0	7	4
Net Score	9	4		0	-1	-2
Rank	1	2	3	3	4	5
Continue	Y	Y	Y	Y	N	N

Figure 22: Pugh selection based on Engineering Characteristics

ECs \ Concept	Concept1	Concept2	Concept3	Concept4
Power consumption		+	-	+
impact strength		-	-	-
material cost		+	-	+
production cost		-	-	-
Hydrophobic		-	-	-
Anti Corrosiveness		-	+	-
Recyclable	D	-	0	-
Average Working Time		-	0	-
Thermal exp.Coefficient	A	-	-	+
Filtering Time		+	-	-
System Bulkiness	T	-	0	+
Thermal Conductivity		-	0	-
Inlet/outlet air Velocity		-	0	-
Body Design	U	0	0	-
Air Filtering Technology		0	+	-
Heat Emission	M	-	0	-
Sum +		3	2	4
Sum -		11	7	12
Sum 0's		2	7	0
Net Score		-8	-5	-8
Rank		3	4	2
Continue		N	N	N

Figure 23: Pugh selection based on Engineering Characteristics 2nd iteration

As the datum(Concept 1 - Pole based suction system) is the only one which get the positive score so we are considering datum as our final concept.

7.2 List of Pros and Cons

1. Underground pollution suction system
    - Pros
        - Requires lesser ground space
        - Centralized filtration provides better efficiency and lesser power consumption.
    - Cons
        - Installation and maintenance cost is high
        - Water logging and rain may produce issue for such design
2. Pole based pollution suction system
    - Pros
        - Can fulfill any type of pollution control requirement
        - Maintenance and installation costs are cheap.
        - Can withstand most weather condition.
    - Cons
        - Is lesser efficient compared to centralized filtration systems
        - Requires fairly enough ground space or installation space
3. Overhead pollution Suction system
    - Pros
        - Is more efficient as it has a centralized filtration system.
        - Can withstand most weather conditions
    - Cons
        - Installation cost is comparatively very high
        - Can create issues with the traffic control
        - Requires large ground space for installation as centralized filter is installed on the ground.
4. Electrostatic precipitation system
    - Pros
        - Lesser suction power required as no pressure is needed to purify the air
        - The electrostatic precipitator doesn't require consistent replacement and cleaning and can work for long
    - Cons

  - Requires a lot of ground space
  - Needs a lot of power to run
  - High humidity in air can affect it adversly

5. Smog sucking vehicles

   - Pros
     - Not limited to a particular place.
     - Can reduce more than other setups for the same amount of time.
   - Cons
     - Power required for filtration is needed to be delivered by the vehicle which would not be efficient.
     - Will require proper maintenance from time to time requires a lot of vehicles to install the setup in order for the solution to make any difference

6. Exhaust smoke purifier

   - Pros
     - This solution in most ideal cases gives maximum efficiency
     - This directly minimizes the major source for air pollution around the world
   - Cons
     - It requires very frequent monitoring and removal of soot from the filter.
     - Maintaining such a setup is exhausting and time consuming
     - It directly affects the performance of one's vehicles and is highly dependent on the amount of people adapting to the solution

8 Embodiment Design

8.1 Block Diagram for the product working

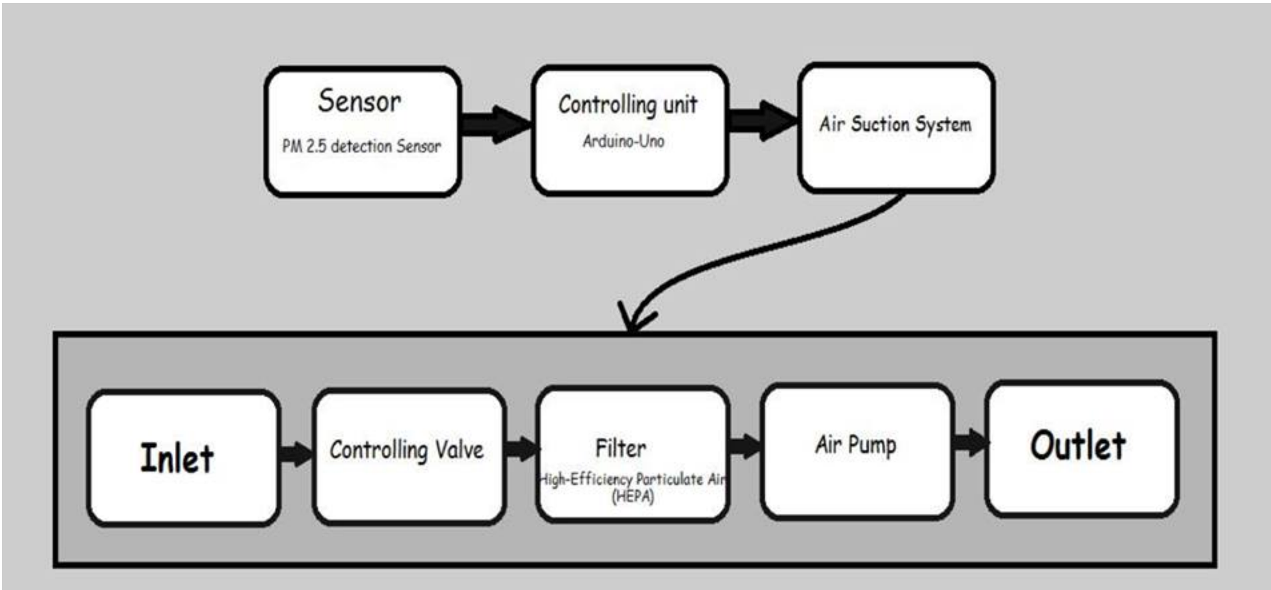


Figure 24: Block Diagram

8.2 Parametric Design Specification

- **Sensor**
  - Working voltage: DC 5.0 (+- 0.5V)
  - Working current(Max): 90mA
  - Humidity Range:Working Conditions 0-95% RH
  - Temperature Range: Working Conditions -20 to 60 degree
  - DSM501 dust sensor can sense more than 1 micron tiny particles.
- **Filter**
  - High Efficiency Particulate Absorber(HEPA) type filtration
  - Effectively removes up to 1 micron particles
  - Helps absorb harmful pollutants such cs VOC's.
  - HEPA filtration removes up to 99.97% of airborne allergens.

- **Air pump**
  - Power Consumption 35W
  - Flow Rate 1030 gal/hr
  - Can withstand humidity of 95%
  - Air Velocity - 8.67-13.33 cm/min
- **Micro controller**
  - Operating Voltage 5V
  - Input Voltage Limits 6-20V
  - Digital I/O pins 14(of which 6 provide PWM output)
  - Analog Input pins 6
  - DC current per I/O pin 40mA
  - DC current per 3.3V pin 50mA
  - Flash Memory 32 KB
  - SRAM 2KB
  - EEPROM 1KB
  - Clock Speed 16Mhz
- **WiFi Module**
  - Wi-Fi :802.11 b/g/n 2.4 Ghz
  - 16MHZ clock speed
  - Built-in processor ESP8266

9 Detail Design

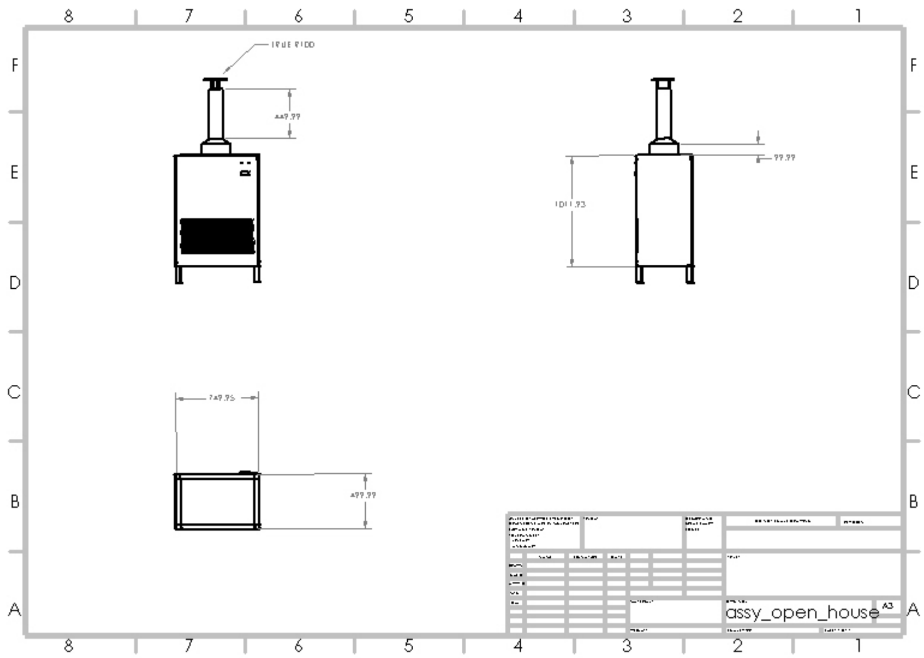


Figure 25: Drawing sheet

Drawing Sheet

9.1 Time Estimation of the Product

ACTIVITY	PREDECESSORS	TIME(In Weeks)	DESCRIPTION
A	--	3	Purchasing(material collection)
B	A	2	Chassis
C	B	3	Finishing Body Parts
D	C	1	Assembling and Component Fixation
E	D	2	Electrical connections
F	D	1	Programming
G	E,F	2	Finishing
H	G	1	Testing

Figure 26: Estimation of Time

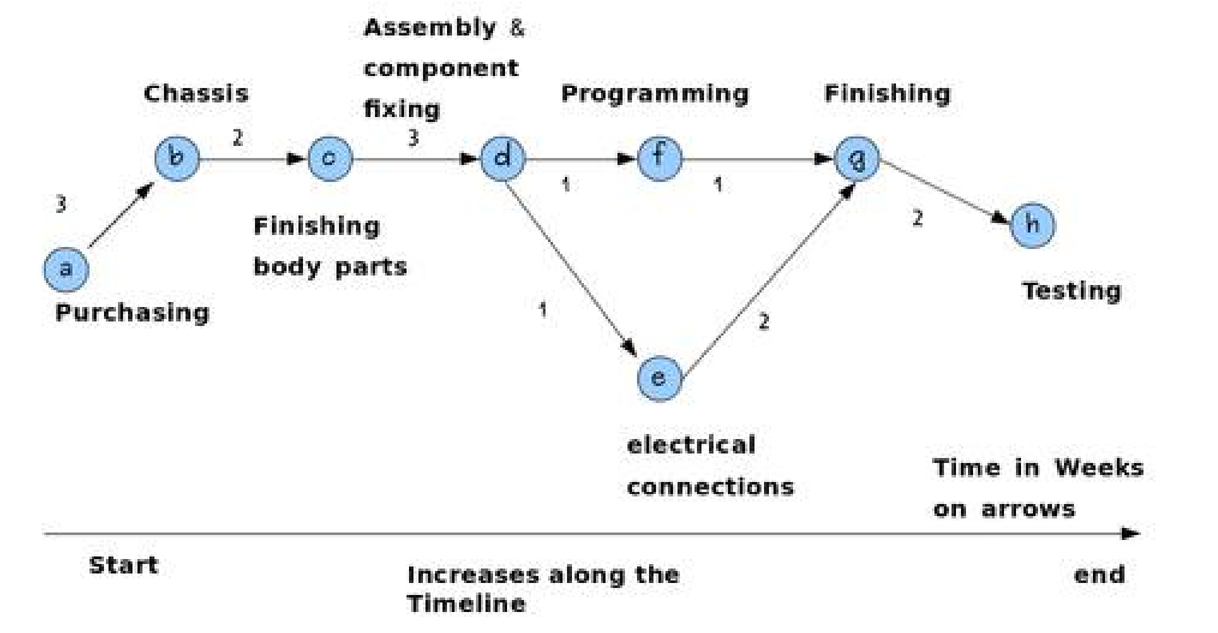


Figure 27: Time Estimation, Activity on Nodes

Critical Path: a-b-c-d-e-g-h

Time in Critical Path: 15 Weeks (Minimum Project Completion time)

9.2 Cost

We calculated the total cost of the internal components as given in the figure 26 (Round Figures).

PRODUCT	COST
MICROCONTROLLER	₹ 500
HEPA FILTER	₹ 800
27 FT. ANGLE IRON	₹ 800
GI SHEET	₹ 1100
EXHAUST FAN	₹ 1200
PM 2.5 TESTING SENSOR	₹1600
EXTRA	₹ 200
TOTAL	₹ 6200

Figure 28: Estimation of Cost

10 Prototype (Physical or Virtual)

Explored View This section contains how the product will look at different stages of its making as estimated in a sequential order.

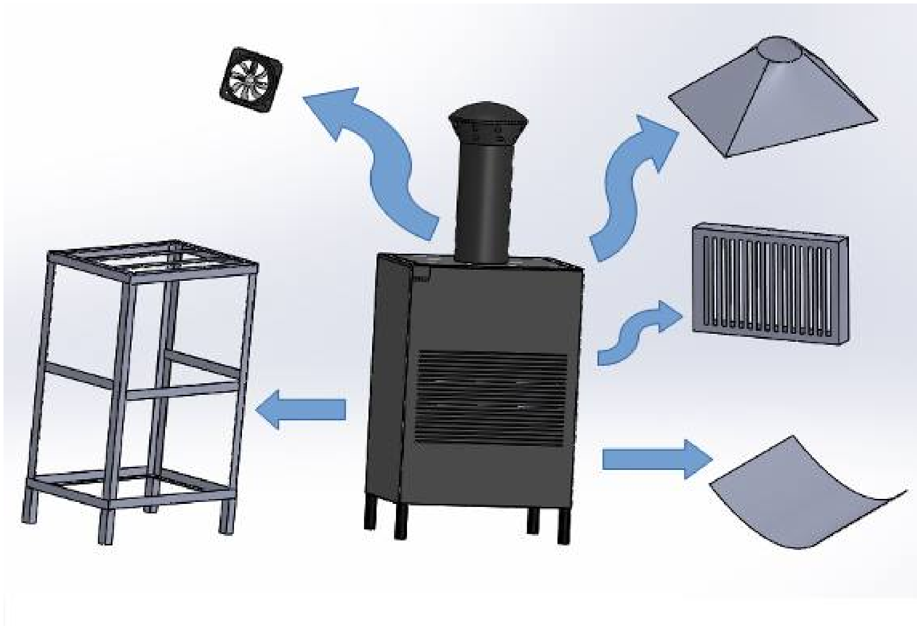


Figure 29: Explored View of the product

10.1 Chassis

Figure 30: Chassis prototype

10.2 Chassis with Fan and vents

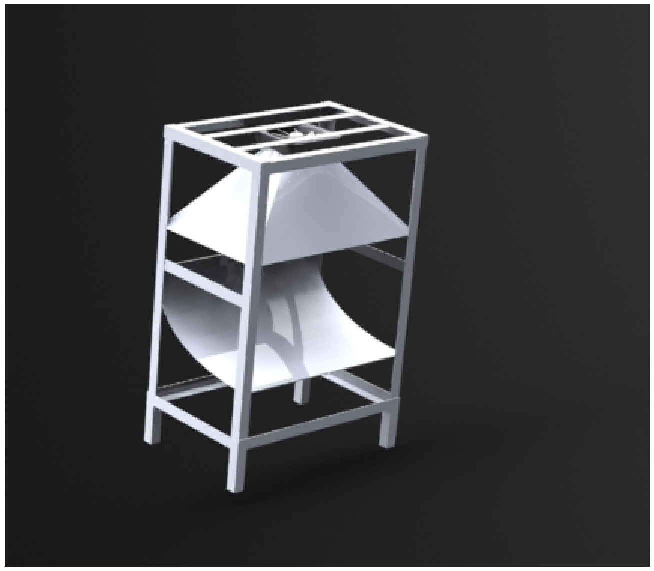


Figure 31: Chassis with Fan and vents prototype

10.3 Front frame attached

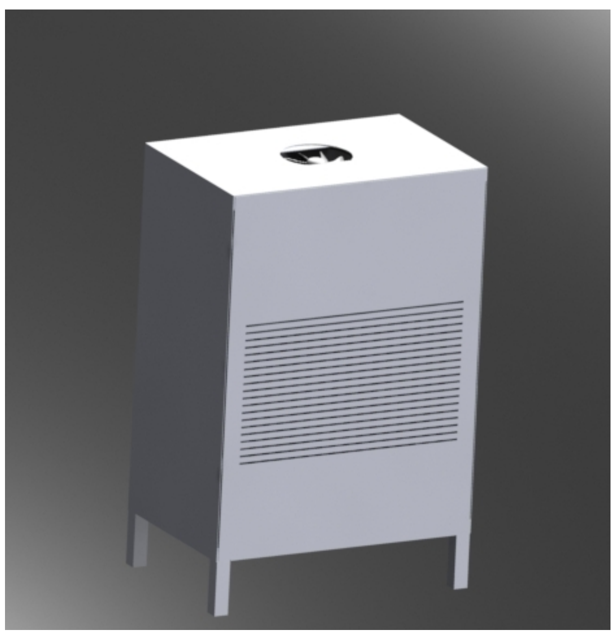


Figure 32: Front frame attached prototype

11 Design Enhancement and Building (physical product)

As all good designs get enhanced as they reach the manufacturing table our design too went through some minor changes during the course of fabrication. The major design changes are listed below:

- The intake does not house the HEPA filter now. As we faced problems with water resistance because of the design we enhanced its location to a mid way bracket housed right below the air tight fan chamber.
- The location of the intake vent too is lowered a bit for better efficiency.
- The Outlet shape has been changed to improve the water resistance of the product

11.1 chassis Building

The angle iron collected from the material collection phase is cut down into required sizes and welded accordingly to our CAD model/design concept to build the chassis.

Figure 33: welded chassis

11.2 Vent Designing and Sheet Cutting

Aerodynamic structure Allows air to pass through the vent separating the polluted air from filtered air thus avoiding the complications. GI Sheet 24 gauge is cut based on the outer body dimensions providing a tough coverage to inbuilt structure .

Figure 34: Vent designing

11.3 Designing Filter case

Filter case protects the fragile HEPA filter from variant conditions thus absorbing only polluted air and releasing the filtered air.

11.4 Composition and electrical connections

After performing suitable operations the components are brought together to integrate and electrical connections for the power supply are made. Thus making our product fit to function.

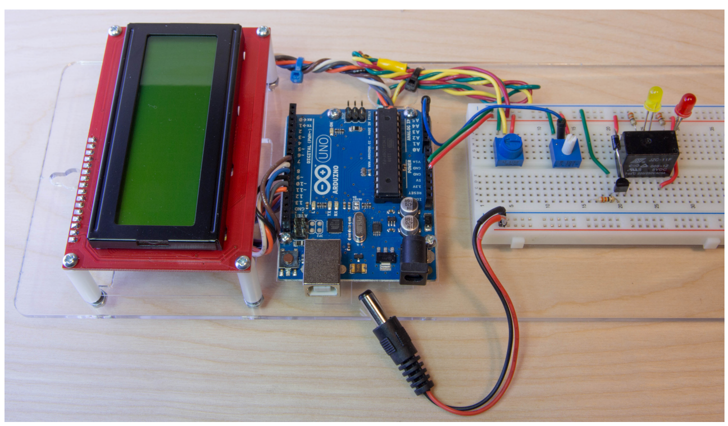


Figure 35: Electrical Connection

12 Testing(physical product)

We divided our testing into 3 phases.

12.1 Form Test

Overall appearance matches the shape and size of the model produced ,satisfying the constraints of environment in which it has to prevail.

12.2 Fit Test

The parts are precisely fit and no protrusions are visible making it aesthetically appealing. Components fit together in the assembly.

12.3 Function Test

The assembly is tested and functions as determined making it easy to maintain.

13 Results

The results that we obtained from Vyom (Product name) are as follows

- Cleaner air around busy roads in major cities.
- Better environment around the more polluted parts of the city.
- Lower **PM10** and **PM2.5** levels for the city resulting in a better quality of air for everyone to breath.
- A reliable system that ensures clean air and better surrounding ensuring conservation of biodiversity around polluted roads.

14 Smart Device

14.1 App Development

An android application is Developed by using MIT app inventor showing various features operated through it providing a complete hands-free experience.Through application we can control complete device through application.

- Controlling complete device through app
- FAN control
- Sensor Control

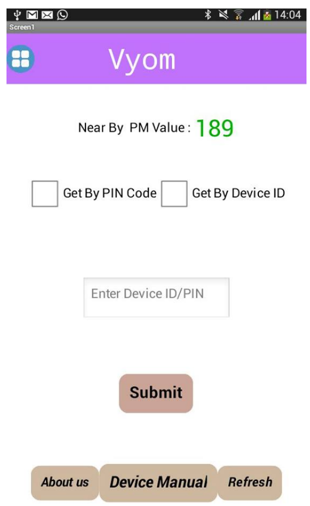


Figure 36: Home Page

14.2 Website Building

This provides geographical information through location- id enabling us to track the devices all over also giving forth pollution level at the particular location through live data streaming.

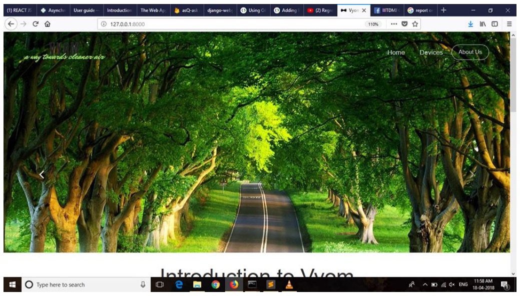


Figure 37: Home Page

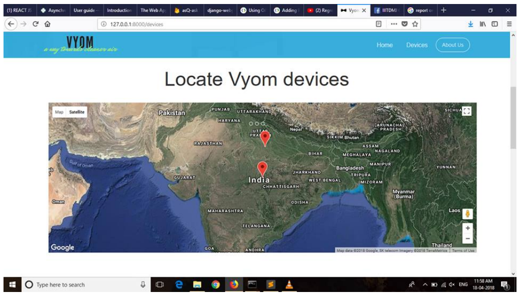


Figure 38: Live Data streaming

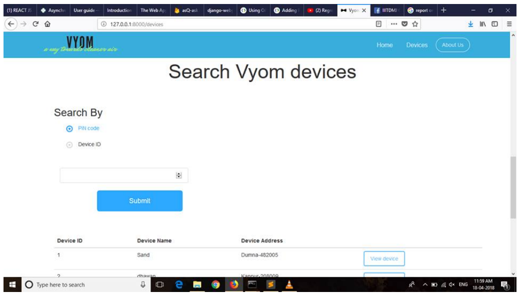


Figure 39: Searches

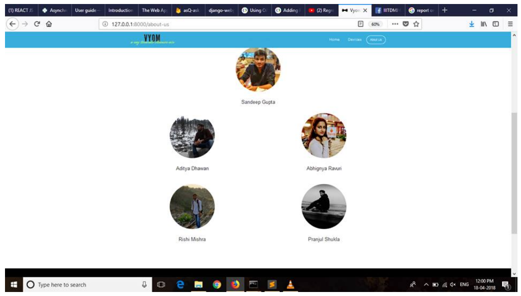


Figure 40: About Us

15 Concluding Remarks

With Vyom we not just aim to reduce pollution but also create a network for pollution monitoring using which governments and other organizations can analyze it to take special actions for places where it is exceeding the safe limits. We have included a wireless communication system in Vyom which helps it to get connected to local network and translate the Air quality data to any server if need be. Through this we can monitor Live pollution levels in places where Vyom is placed.
We have also included an android application to control the features of Vyom with the help of a Bluetooth module installed in Vyom. The application is able to control almost all features that Vyom. The application is another abstraction provided to the users to control Vyom in a truly advanced manner.
We have also created a website that shows one of the many ways in which we can use Vyom to monitor Air quality in different areas in real time. The website incorporates features like live Air quality detection for all Vyom devices connected to the server, location based Vyom searching, location based air quality estimate and much more. The website is just an example of how Vyom can be used to reduce and analyze pollution at the same time.