

# Study on Smoke Adsorbing Central Median Barrier for Road Pavement

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**ABSTRACT:** The purpose of this project is to reduce the building rate of pollution in our country. The scenario that everyone facing today is mainly due to air pollution. So this project aims to reduce air pollution to an extent. Vehicle emits a lot of pollution these days. Either when they are running or when they are standby in traffic signals. The project focuses on adsorbing the pollution that is produced by the vehicles, through a “Smoke Adsorbing Central Median Barrier”. The central median barrier is fixed with a chamber consisting of activated charcoal; these charcoals adsorb the polluted air and filters it as a clean air. Due to its adsorbing property it reduces the amount of carbon monoxide carbon dioxide and hydrocarbons present in the air pollution. The barrier was designed for the distance of 25 meter in each direction an internal chamber of 150 mm diameter was designed in the bottom portion of the barrier to adsorb air pollution near traffic signals. This is one of the most effective and efficient ways to reduce pollution.

By executing this project the pollution near the traffic signals can be treated effectively and efficiently.

**KEYWORDS:** Pollution; Traffic Engineering; Innovative Barrier construction methodology; Sustainable Development.

## I. INTRODUCTION

This study mainly deals with the application of central median barriers that adsorb and filters the vehicle emissions when pollutant adsorbing materials are combined with the barrier structures internally. The adsorbent materials such as Activated Charcoal, Zeolite, polymeric adsorbents, Silica gel, Activated Alumina, Activated Carbon pre-filter may be used.

As the vehicle produces more smoke it gets adsorbed by the adsorbents materials and hence can produce ideal results in reducing the smoke content in the atmosphere. The need for smoke adsorbing central median barrier is to improve the existing median structure by playing additional role with the lane dividing purpose. Since transportation contributes higher amount of pollutants, especially in roadway transports. This project helps in reducing the air pollution to some extent.

The adsorption and filtration of pollution is required in big cities due to the following reasons

- a) Volume of the air pollution is increased
- b) Due to increase in the number of vehicles
- c) Due to depletion of ozone layer
- d) Acid rains can be stopped
- e) Reduce the chances of respiratory and heart problems

## II. CENTRAL MEDIAN BARRIER

It is a modular concrete barrier that separate lanes of traffic and it is designed to minimize vehicle damage in case of incidental contact. These are used to re-route traffic and protect pedestrians and workers during highway construction as well as temporary and semi-permanent protection against land bone attack such as suicide vehicle bombs etc.,

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**Modification of Barrier:** The project deals with the modification of the existing central median barrier with three chambers located at the bottom of the barrier which adsorbs and filters the pollution from the vehicle near traffic signals. The three chambers are made of poly vinyl chloride pipe consisting of inhaler fan on the first layer. Activated charcoal or Silica gel in the second and Activated carbon Pre-filter or sponge filters on the end.

**Working of Model:** Traffic signals are one of the major reasons for pollution in big cities. So the adsorption chambers are placed inside the barrier which adsorbs smokes which are emitted by vehicles. These smokes get filtered through a layer consisting of Activated charcoal or Silica gel. The filtered smoke is passed on to Activated carbon pre-filer or sponge filter which retains the dust and small particles in powdered form. The purified air passes out of the other end of the chamber.

### III. OBJECTIVES OF THE STUDY

The objectives of the study are

- To modify existing structure of the central median barrier and indulge internal adsorbent chamber on it.
- To explore the properties of the adsorbents.
- To control air pollution thus protecting environment and aesthetics along the roadways.
- To make use of the space in between roads.

### IV. LITERATURE REVIEW

Oscar Ruthven, D. M (1984) has conducted a research on adsorption and separation process in industries, particularly in petroleum refining and petroleum chemical industries. It main emphasis on the understanding of adsorption dynamics and the modeling of adsorption system but some of the more fundamental concepts of adsorption kinetics and equilibrium are covered in a greater detail for understanding of adsorption column dynamics. These subjects are central to an understanding of adsorption phenomenal and to provide theoretical frame work. Attempt has been made to provide a comprehensive review of all important adsorption separation process.

Ming Qi (1993) carried out the pressure transient tests in a steam filled core were carried out. Eight different rock samples were tested and the adsorption isotherm parameters were estimated by using nonlinear regression. The pressure transient curves were obtained and from them the adsorption isotherm parameters were inferred. Preliminary results show that the nonlinear regression method can be applied to adsorption related thermal reservoir studies. It was also; found that differences in reservoir permeability and porosity did not affect the characteristic shape of the isotherm curves derived by using this estimation procedure.

Cooney, D. O (1999) defines the basic principle of adsorption, emphasizing practical aspects of adsorbent selection after this there is an brief introduction is qualitative description of common adsorbent followed by an overview of important quantitative adsorbent characteristics and finally some case studies illustrating the main ideas of adsorption technology or adsorber design. Although most of the topic discussed here are given in greater detail including adsorption along with carbon, silica gel, reactive polymers, zeolites and others.

Buekens. A and Zyaykina .N. N (2003) briefly covers the major technical issues related to industrial adsorbents and their application in gas cleaning and desiccation. Fixed, moving, and fluidized bed types of adsorbents are schematically shown and their operation principles are discussed. General guidelines for an adsorber design are presented: however, they are mostly limited to the most usual case of the fixed-bed adsorber. Several approaches, based on theoretical models for calculation of breakthrough curves, are outlined. Formulas for calculation of the essential parameters such as pressure drop and bed length are explained. Finally, the attention is drawn to some safety aspects, which should be considered while operating an adsorber.

Ahmaruzzaman (2008) describes the adsorption techniques that are widely used to remove certain classes of pollutants from wastewater. Phenolic compounds represent one of the problematic groups. Although commercial activated carbon is a preferred adsorbent for phenol removal, its widespread use is restricted due to the high cost. As such, alternative non-conventional adsorbents have been investigated. The natural materials, waste materials from industry and agriculture and bio adsorbents can be employed as inexpensive adsorbents. There are several issues and drawbacks concerned on the adsorption of phenolic compounds that have been discussed in this review article. It is evident from the review that low-cost adsorbents have demonstrated high removal capabilities for certain phenolic compounds. In particular, industrial waste might be a promising adsorbent for environmental and purification purposes.

Dabrowski . A (2008) has studied the adsorption of phenol and its derivatives on activated carbons is considered

based on numerous papers related to this issue. Special attention is paid to the effects of carbon surface functionalities, pH of solution and heterogeneity effects that accompany adsorption of phenolic compounds. Moreover, in this paper the most important aspects are overviewed referring to irreversible adsorption of phenols and impact of different substituents of phenolic compounds on their uptake by activated carbons is considered. Finally, some remarks pertaining to applications of novel adsorbents for phenol adsorption are discussed and illustrated by means of a few examples.

Ahmed rezk masoud (2012) has carried out test for the improvement and performance of silica gel / water adsorption cooling systems using a number of investigation tools. A novel global analytical simulation model has been constructed for a commercialized two-bed silica gel / water 450kW adsorption chiller. The model has been constructed based on the fundamental heat and mass transfer equations. It was integrated with a genetic algorithm (GA) optimization toolbox to determine the optimum operating conditions to obtain the optimum chiller performance. The model was used to investigate the effect of physical and operating conditions including configuration, cycle times and secondary fluid flow rate on the chiller performance.

ShivajiBhandarkar (2013), has described that the emission from vehicles especially automobiles is responsible for about two third of air pollution in the urban area. The major pollutants emitted by motor vehicles including CO, NO<sub>x</sub>, sulphur oxides, (SO), HC, lead (Pb) and suspended particulate matter (SPM), have been damaging effects on both human health and ecology. The internal combustion engines need a mixture of air and fuel to burn and produce energy to propel the vehicle. These burnt gases which come out of the exhaust are responsible for pollution. In petrol engines, the gases comprise a mixture of unburnt hydrocarbons (HC), Carbon Monoxide (CO) and Oxides of Nitrogen (NO<sub>x</sub>). If these gases are in excess quantities, vehicular pollution is caused. Emissions of Diesel vehicles are the concentration of CO and unburnt HC in the diesel exhaust are rather low, both of which are compensated by high concentration of NO<sub>x</sub> and CO<sub>2</sub>. There are smoke particles and oxygenated HC, including aldehydes and odor- producing compounds.

This paper initially presents various types of pollution emitted by vehicles, their effect on human health and mitigation measures by the use of various new technologies of Automobile Engineering and Alternative fuels.

## 5. METHODOLOGY

The review of literature describes about the emission from vehicles especially automobiles which is responsible for about two third of air pollution in the urban areas to minimize the air pollution using adsorbents. The materials were collected for the comparative study in which Activated charcoal and Silica gel are used.

The design of the filter median is carried out with inhaler fan of 100mm diameter fixed to the poly vinyl chloride pipe of diameter 150mm. A layer of Adsorbent material is introduced in the center portion of the median and Activated carbon pre filter is provided at the end. Each barrier consists of three filter medians according to the size of barrier.

The Adsorption test and Filtration test using Activated charcoal, Silica gel were conducted. A miniature setup was made to check the efficiency of the material in the real time and the preparation of model was made in the larger scale and placed in between the reinforcement at the bottom portion of barrier.

The Activated charcoal gives better results due to its porosity which adsorb gases on its surface and it is economical so it is adopted to adsorb the vehicle emissions along roadways Thus from the above study the activated charcoal has been used for adsorption and filtration of CO<sub>2</sub> eliminated by the vehicles in traffic signals. Figure 5.1 showing the methodology of smoke adsorbing central median barrier.

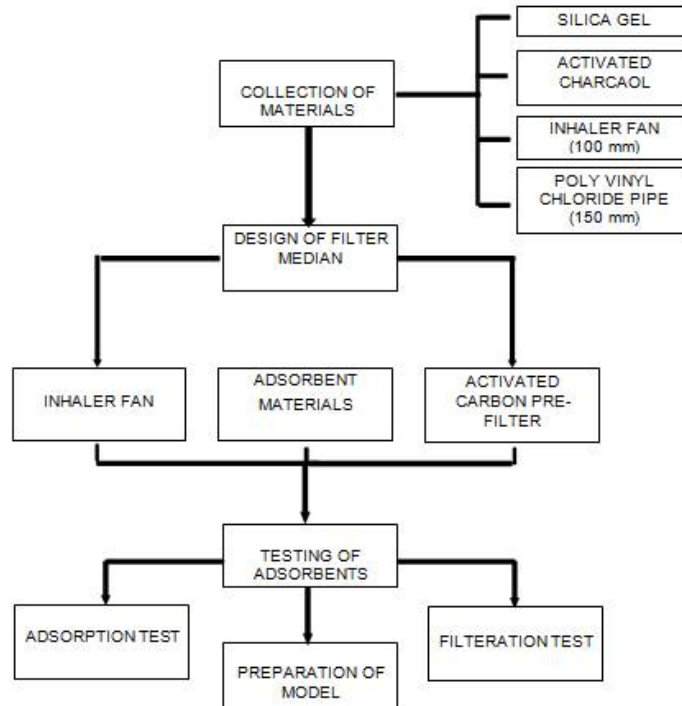


Figure 5.1 Flow Chart of Smoke Adsorbing Central Median Barrier

### 5.1. Study area

The project covers all the traffic signals consisting of concrete barriers in the padapai junction at a distance of 25 meter in each direction. The traffic signals are one of the major reasons for air pollution.

Almost all the vehicle produces carbon dioxide and carbon monoxide smokes which are being absorbed by the concrete barrier and are treated with adsorbent materials near traffic signals. All the aspects of traffic signals, its pollution growth rate was to be considered during the design of Smoke Adsorbing Central Median Barrier.



Figure 5.2 Map showing the study area

### 5.2. Site visit

A site visit to construction of concrete barrier at Padapai from Highway Research Department Figure 3.3 shows the construction of Concrete Barrier at Padapai.



Figure 5.3 Construction of Concrete Barrier at Padapai

### 5.3. Design Considerations

#### 5.3.1. General

All the aspects of traffic signals, its pollution growth rate and characteristics of adsorbents were to be considered during the design of smoke adsorbing central median barrier.

#### 5.3.2. Roadway Pollution (Vehicular Pollutants)

In roadway pollution the transport sector contributes around 14% towards the global emissions of greenhouse gases. The road transport alone emits around 16% of the global CO<sub>2</sub> emissions. Figure 3.4 shows the emission of CO<sub>2</sub> by mode of transport





Figure 5.4 Emission of CO2 by Mode of Transport

Source: International Transport Forum / International Energy Agency

### 5.3.3. Vehicle Pollution Testing

The vehicle pollution testing was carried out with Computerized Pollution under Control (PUC) system. The Pollution under Control (PUC) norms for in-use Petrol/CNG/LPG vehicles were notified by Ministry Of Road Transport and Highways for implementation throughout the country. The results of vehicle pollution testing was that the amount of carbon dioxide and carbon monoxide has the largest proportion of greenhouse gas emissions which may have greater effect on ozone layer Figure 3.5 shows the pollutants contribution in roadway pollution.

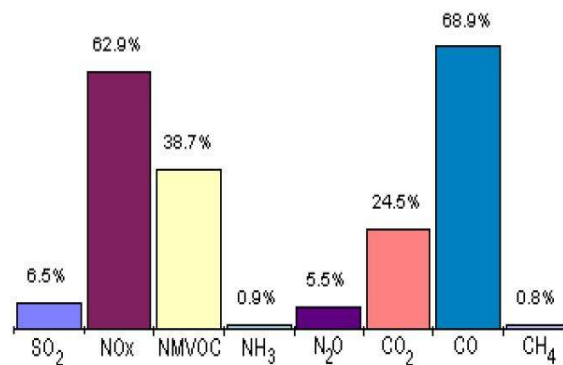


Figure 5.5 Pollutants Contribution in Roadway Pollution

Source: Pollution Control Board (Chennai)

## 5.4 SMOKE ADSORBING MATERIALS

### 5.4.1 General

There are some materials which adsorb smoke such as Activated Charcoal, Silica gel, Zeolite, Activated Alumina and Activated Carbon pre filer.

### 5.4.2 Activated Charcoal

Activated Charcoal is formed when carbon containing compounds are heated in a limited supply of air (called pyrolysis).

Activated charcoal has wide variety of uses the major use for controlling air pollution due to porosity it can adsorb gases on its surface. Therefore, it is used in water filters and gas masks. Since, activated charcoal is economic and so it is adopted to adsorb the vehicle emissions along the roadways. Figure 5.6 shows the typical view of Activated Charcoal.

Figure 3.6 Activated Charcoal

#### 5.4.3 Silica Gel

Silica gel has an amorphous structure and was described by the general formula  $\text{SiO}_2 \cdot n\text{H}_2\text{O}$ . The adsorption ability and chemical properties of silica gel largely depends upon on the presence of structural Si-OH groups on their surface.

Silica gels are subdivided into three classes according to their pore size

- large pores ( $\approx 5 \text{ nm}$ )
- Medium pores (5 - 1.5 nm)
- Small pores (1.0 - 1.5 nm)

Figure 3.7 shows the silica gel of (1.0- 1.5 nm).



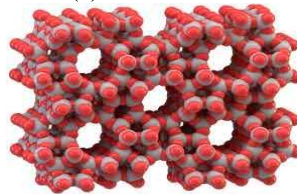
Figure 5.7 Silica Gel

#### 5.4.4 Zeolite

Zeolites were also called molecular sieves. They are crystalline silicates with a general chemical formula  $\text{Me}_2/n\text{O Al}_2\text{O}_3 \cdot x \text{SiO}_2 \cdot y \text{H}_2\text{O}$  containing oxides of alkali- or alkali-earth metals (Na, K, Ca) and characterized by regular structure of the average pore diameter 0.3nm – 1nm. The adsorptive capacity of zeolites depends upon molecular size and shape of the sieves which was typically less than one nanometer. Figure 3.8 shows the structure of Natural and Molecular Structure of Zeolite.



(a) Natural zeolite



(b) Molecular Structure of Zeolite

Figure 5.8 Zeolite

#### 5.4.5 Activated Alumina

It was produced from hydrated alumina by dehydration under carefully controlled conditions. It is hydrophilic, amorphous with general formula  $\text{Al}_2\text{O}_3 \cdot n\text{H}_2\text{O}$ . It is used as an adsorbent material for removal of oxygenates from hydrocarbon feed streams, fluoride ions from water, etc.

The Common forms of Activated alumina are:

- Balls
- Granules
- Pellets
- Powder

Figure 5.9 shows the typical view of Activated Alumina.



Figure 5.9 Activated Alumina

#### 5.4.6 Activated Carbon Pre filter

The Activated carbon pre filter serves as a premium defense in capturing small airborne particles and removing odors such as dust, smoke, lint and fibers. The activated carbon pre filter was also ideal for establishing a safe and healthy environment by reducing common odors and gases. Figure 3.10 shows the Activated Carbon Pre Filter.



Figure 5.10 Activated Carbon Pre Filter

#### 5.4.7 Properties of Adsorbents

The most important technical adsorbents are activated charcoal and silica gel. This was used for almost all the adsorption and filtration purposes.

Typical requirements for commercial adsorbents are:

- It should have high porosity.
- It should high internal surface.
- High adsorption efficiency in a wide range of adsorbate concentrations.
- Good balance between macro-pores (for fast internal transport) and micro-pores (for large internal surfaces).
- Hydrophobic chemical structure (for treatment of moist gases) unless the adsorbent was to be used as a desiccant
- Mechanical integrity during handling.
- Low cost for acquisition (and eventually disposal) of adsorbents.



The main characteristics of technical adsorbents are shown in the Table 5.1

Table 5.1 Main Characteristics of Technical Adsorbents

Adsorbent	Nature	Average pore diameter, nm	Particle porosity, %	Surface area, m <sup>2</sup> g <sup>-1</sup>	Adsorptive Capacity, kg kg <sup>-1</sup> (dry)
Activated alumina	Hydrophilic, amorphous	4 – 14	50	320	0.1-0.33
Activated charcoal	Hydrophilic, amorphous	1 - 4	40 - 85	200- 1200	0.3– 0.7
Zeolites	Hydrophilic, crystalline	0.3 -1	20 - 50	600 - 700	0.12-0.42
Silica gel	Hydrophilic, amorphous	2 - 5	47 - 71	300 - 850	0.35 – 0.5

Source: 'Perry's Chemical Engineers' Handbook, 7th edition

## 5.6 DESIGN OF FILTER MEDIAN

### 5.6.1 General

All the aspects of central median barrier, environmental condition along road ways and characteristics of adsorbents were to be considered during the design of filter median for smoke adsorbing central median barrier.

### 5.6.2 Filter Median

The filter median was made up of poly vinyl chloride pipe with a diameter of 150mm. it consists of three components

- Inhaler fan
- Adsorbent materials
- Activated carbon pre filter

The inhaler fan of 100mm diameter was fixed to the poly vinyl chloride pipe of diameter 150mm. A layer of Adsorbent material is introduced in the centre portion of the median and Activated carbon pre filter is provided at the end

Each barrier consists of three filter medians according to the size and standards of the barrier Figure 3.11 (a) shows the cross section of filter median and Figure 3.11 (b) shows the isometric view of filter median.

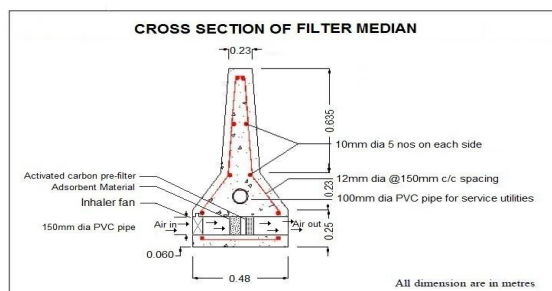


Figure 5.11 (a) Cross Section of Filter Median

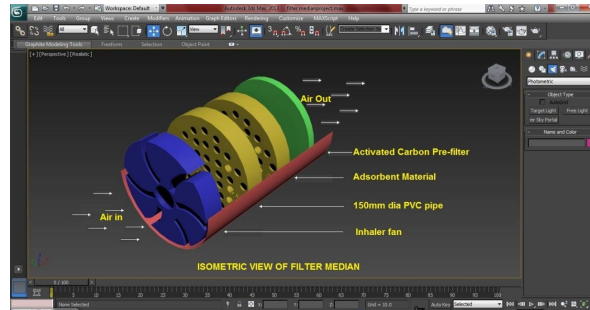


Figure 5.11 (b) Isometric View of Filter Median

## 5.7 TESTING OF ADSORBENTS

### 5.7.1 General

The Adsorption test and Filtration test have been carried out for smoke adsorbing central median barrier according to the standards of Adsorbents.

### 5.7.2 Adsorption Test

This test is carried out to determine the amount of smoke adsorbed in sample by the method of adsorption Figure 3.12 shows the setup of Adsorption Test.



Figure 5.12 Adsorption Test

The increase in weight was calculated by (Adsorbed weight of sample – Initial weight of sample)

Apparatus required:

- i) Adsorbent materials
- ii) Air-tight bottles
- iii) Weighing balance
- iv) Smoke from Diesel / Petrol engine

Procedure:

- Clean the bottles and dry it.
- Take the required quantity of the sample in the bottles.
- These air-tight bottles should be exposed to direct smoke emission from the vehicle which is of diesel / petrol engine.
- The four air-tight bottles are kept for different times (Normally for 30 min, 60 min, 90 min and 120 min) respectively.
- When the time is completed, remove the samples from the bottles and weigh it.

### 5.7.3 Filtration Test

This test is carried out to determine the amount of smoke filtered in sample by the method of filtration Figure 3.13 shows the setup of filtration test.



Figure 5.13 Filtration Test

Apparatus required:

- i) Air-tight bottles
- ii) Weighing balance, with an accuracy of 1g
- iii) Inhaler fan (100mm diameter)
- iv) An air-tight box
- v) Two rectangular plates consisting of small pores

Procedure:

- Clean and dry the air tight box.
- Fix the inhaler fan at one end and activated carbon pre filter at the another end.
- Take the rectangular plates consisting of small pores and place in the air tight box at the distance of 50 mm apart from each other and fill the area with the sample.
- The air-tight bottle (1) was exposed to direct smoke emission from the vehicle which is of diesel / petrol engine
- Collect the smoke in air-tight bottle (1) and weight it.
- The air-tight bottle (2) is fixed at the extreme end of the box.
- The inhaler fan is turned on.
- The smoke from the air-tight bottle1 is released through inhaler fan; it gets filtered through sample and activated carbon pre-filter.
- The filtered smoke is captured in the air-tight bottle 2.
- The difference in weights of the bottles gives the amount of smoke filtered.

## 5.8 PREPARATION OF MODEL

### 5.8.1 General

The central median barrier is selected from latest design in existence as recommended by the Public Work Department (PWD).

### 5.8.2 Inhaler Fan

Small inhaling electronic device is fitted at the bottom portion of the internal chamber. It Inhales the vehicle exhaust as emitted, before complete dissipation into the atmosphere. The electrical connections given for inhaler fans is from the service utility pipe installed already in the barrier. Figure 3.14 shows the inhaler fan of 100 mm diameter.



Figure 5.14 Inhaler fan

### 5.8.3 Internal Chamber

This chamber is made up of poly vinyl chloride pipe which is non-corrosive in nature. It provides sufficient area for Pollutant Adsorption and filtration. This chamber provides an area on the center portion for samples to be placed. Figure 3.15 shows the model of internal chamber.



Figure 5.15 Internal chamber

### 5.8.4 Openings

The openings were provided in the internal chamber only for the purpose of replacement of the adsorbent materials in this chamber

### 5.8.5 Reinforcement Detail

The reinforcement detail was selected from latest design in existence as recommended by the Public Work Department (PWD). The main reinforcement is 12 mm diameter @150 mm c/c spacing and the distribution rod is 10 mm diameter distributed on each side. Figure 3.16 shows the reinforcement detail of central median barrier.



Figure 5.16 Reinforcement Detail



## VI. RESULTS AND DISCUSSIONS

### 6.1 GENERAL

The test for smoke adsorbing central median barrier was carried out by adsorption test and filtration test. The materials such as activated charcoal and silica gel were compared and the following results were obtained.

### 6.2 RESULTS

#### 6.2.1 Adsorption Test

Activated charcoal

Initial weight of sample = 100 grams

Table 6.1 Adsorption test with Activated Charcoal

Sample	Initial weight of sample	Weight of sample after adsorption (grams)	Increase in weight (grams)
30 min adsorbed smoke sample	100	100.23	0.23
60 min adsorbed smoke sample	100	100.35	0.35
90 min adsorbed smoke sample	100	100.59	0.59
120 min adsorbed smoke sample	100	100.78	0.78

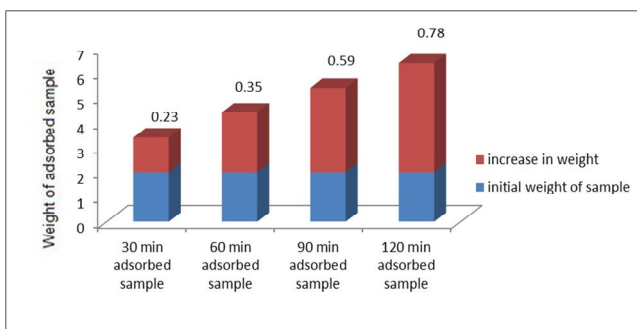
Silica gel

□ Initial weight of sample = 100 grams

Table 6.2 Adsorption test with Silica Gel

Sample	Initial weight of sample	Weight of sample after adsorption (grams)	Increase in weight (grams)
30 min adsorbed smoke sample	100	100.10	0.10
60 min adsorbed smoke sample	100	100.15	0.15
90 min adsorbed smoke sample	100	100.27	0.27
120 min adsorbed smoke sample	100	100.29	0.29

#### 6.2.2 Comparison Chart Activated Charcoal



Silica gel

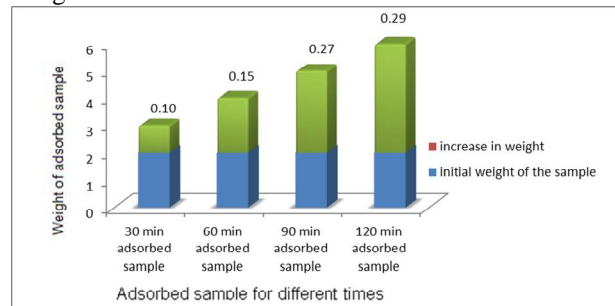


Figure 6.1 Comparison of Adsorption Test between Activated Charcoal and Silica Gel



### 6.2.3 Filtration Test

Activated charcoal

- Initial weight of sample = 100 grams
- Weight of the bottle 1 = 24.51 grams
- Weight of the bottle 2 = 24.48 grams

Table 4.3 filtration test with Activated charcoal

Sample	Trail 1	Trail 2
Weight of bottle 1 + smoke (grams)	24.89	24.91
Weight of bottle 2 + smoke after filtration (grams)	24.69	24.69
Decrease in weight (grams)	0.28	0.23

Silica Gel

- ▶ Initial weight of sample = 100 grams
- ▶ Weight of the bottle 1 = 24.51 grams
- ▶ Weight of the bottle 2 = 24.48 grams

Table 4.4 filtration test with Silica Gel

Sample	Trail 1	Trail 2
Weight of bottle 1 + smoke (grams)	24.93	24.81
Weight of bottle 2 + smoke after filtration (grams)	24.71	24.67
Decrease in weight (grams)	0.22	0.14

### 6.3 DISCUSSIONS

- The increase in inhaler fan size will tend to adsorb more pollution from the vehicles.
- Adding more sodium chloride to charcoal in pyrolysis process will increase its efficiency so that it doesn't need to be replaced often.
- Using of solar power to run the inhaler fan will help in saving the cost of electricity.
- Same technique can be used in industry chimney outlet to minimize the pollution.

## VII. CONCLUSIONS

Environmental, chemical and civil engineering aspects were considered during the design of Smoke adsorbing Central median barrier. Since the roadway transport contributes the higher amount of pollution. As per Indian Standards, the design of Smoke adsorbing Central median barrier was carried out. The internal chamber and filter median was designed. The procedure was checked and found to be correct. The Smoke adsorbing Central median barrier was designed perfectly to adsorb the pollution eliminated by the vehicles

By modifying the Central Median Barrier we are able to trap all the harmful gases like carbon dioxide, carbon monoxide and hydro carbons from the diesel and petrol engines. This will reduce the damage caused in ozone layer.

The Smoke adsorbing Central median barrier was recommended for road pavements in traffic signals.

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