International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Designing Eco-Friendly, Home-Made, Air Purifier Face Mask using Power of Activated Carbon: A Case Study from Delhi

Kaartik Issar

Student, Grade XI, Springdales School, Pusa Road, Delhi, India

Abstract: ***Delhi is one of the most polluted cities in the world. The level of air pollution in Delhi remains severely high all through the year and sometimes it gets alarmingly high. Living in Delhi without pollution safety gadgets is putting one's health at a major risk. Delhi has a lot of migratory population who are daily wagers from various parts of the country. These poor people cannot afford expensive air purifier face mask. The present paper describes the process of making an eco-friendly, cost effective, homemade, scientific air purifier face mask. The mask was designed using biodegradable, recyclable and sustainable jute cotton fabric, fitted with activated carbon beds. The dimensions of the mask were finalized after a pilot trial with people in different age group. Final testing of the mask was done using oximeter followed by a questionnaire on a sample of 65 people.***

Keywords: Air pollution; Activated Carbon, Air purifier, Face Mask, Eco-friendly

1. Introduction

On November 06, 2018, Delhi recorded severe plus emergency due to extreme level of air pollution. The PM2.5 level (pollutant particles in the air with a diameter less than 2.5 micrometres) was recorded 365 μm^3 and PM10 level (pollutant particles in the air with a diameter less than 10 micrometres) was recorded 503 μm^3 which was much beyond the considered severe- plus emergency level PM 2.5 levels above 300 μm^3 and PM10 levels above 430 μm^3. (Reported by Central Pollution Control Board, India).

A year earlier…..
On November 8, 2017 Delhi, the capital city of India, was labelled as the most polluted city of the world (US, State Department). The condition of the air was so bad that medical experts declared health emergency, schools were shut and hospitals were filled with patients suffering with pollution related illness. Many International airlines cancelled their flights. Mr. Arvind Kejriwal, Chief Minister, Delhi, declared the city as gas chamber. (Arvind Kejriwal, 2017)

Though the air pollution level in Delhi remains significantly high all throughout the year, it becomes alarming in the months of October onwards due to vast burning of stubble in the neighbouring agricultural cities. Though government takes many proactive steps such as restricting the number of vehicles on the road and stopping all kind of construction work in the city, these are not enough to deal with problem of this magnitude.

There are many kinds of air pollution mask available in the market. People who can afford to purchase, start wearing the air pollution mask. The average cost of an effective mask is 120-150 Indian rupees. People who struggle to meet even the basic needs of food and shelter cannot afford buying a mask and hence forced to breathe poisonous air.

The present paper describes the making of an eco-friendly, economical and user friendly mask which can be made at home. The paper is divided into two sections. Section I describes the nature of air pollution and section II describes the design of home-made air purifier face mask.

Section I
Nature of air pollution
Air pollutant is the presence of gaseous, aerosol and particulate matter in the atmosphere. Particulate matter is the term used for tiny particles of solid or semi-solid form present in the atmosphere. Particulates are measured based on their size measured in micrometres *(μm).* Particulates of different sizes behave differently. Table I summarizes the behaviour of particulates of different sizes:

Table I: Description of Air Pollutant Particulates

Particulate Size ***(μm)***	Behaviour with air
10 to 50	easily mix up into air
> 50	settle out of the air
< 10	referred as PM10 or coarse particulate
	smoothly mixes in air
	and easily inhaled by humans
< 2.5	referred as PM2.5 or fine particulate
	easily pass through lungs and can remain there for longer duration harming lungs

Particulates above 10 μm are mostly sand and dust particles blown by the wind. Particulates of 0.1 μm to 10 μm are mainly man made and easily get into the atmosphere due to human activities. Fine particulates (< 2.5 μm) include wind dust, sulfate, strong acids, ammonium, nitrate, organic compounds, metal traces and impure water. Coarse particulates (< 10 μm) are emitted from the vehicles, factories, crushing and grinding activities during constructions, dust from road, demolition, burning of coal, paddy fields, plastic, fossil fuel and other such activities. Air quality index (AQI) is a numerical value that is used to describe quality of air. It ranges from 0 to 500 μm^3. Higher the value of AQI, higher the presence of pollutants in the air. Air pollution is largely responsible for respiratory problems,

cardio-vascular problems and neurological problems in humans, particularly in kids and elderly people.

Section II

Description and working of Eco-friendly Air Purifier Face Mask

The function of air filter is based on the process of *Adsorption.* Adsorption is a process of deposition of molecules onto a surface. The surface on which molecules get deposit are called adsorbate and the molecules that are deposited called adsorbed. During the process of air purification, adsorption helps pollutant molecules to stick to the surface. Any air purifier mask works on the process of filtering out pollutant particles from the air. Carbon molecules possess high level of adsorption quality. When carbon molecules are activated, it increases the surface area of carbon lattice and gives more space to pollutant substances to stick to the surface. Carbon based air filters are designed to trap air pollutants. When polluted air pass through the carbon based air filter, pollutant particles get stick to the carbon bed and pollutant free cleaner air comes out of it. Basic carbon molecules are activated (treated) in a controlled temperature to create low volume pores for increasing its'adsorptive ability and increasing its 'surface area making it highly pores. (LiqingLi , Zheng Sun , Hailong Li & Tim C. Keener, 2012).

The proposed mask uses following three special features:

1) Activated carbon as a filtration constituent;
2) Replaceable activated carbon bed;
3) Ecologically safe and porous jute cotton fabric.

The mask uses three-layer protection design. It is made up of biodegradable, recyclable and sustainable jute cotton fabric at the outer most layer and soft cotton fabric in the inner most layer. The middle layer works as a pocket to place the filter bed made up of activated carbon packed in the filter paper/paper towel. Below diagram (Figure I) explains the design of the mask:

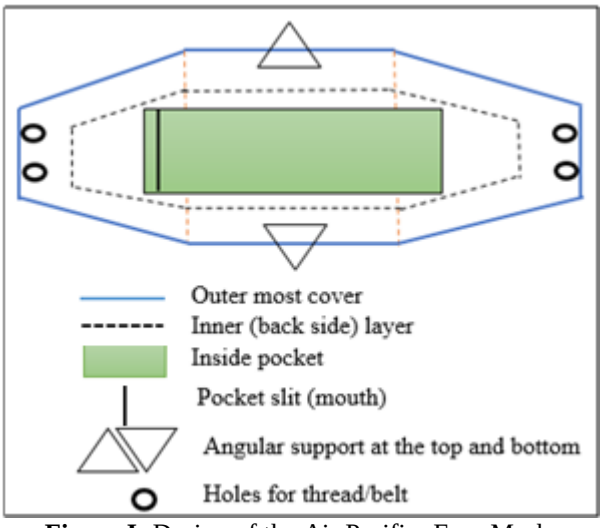

Figure I: Design of the Air Purifier Face Mask

It uses non-synthetic jute cotton fabric for all the three layers (outer most; inner (back side) and the pocket layer) instead of synthetic fabric. People who suffer from any kind of allergy are not very comfortable using synthetic fabric as it aggravates the allergy symptoms. Also, India being one of the largest producer of jute and cotton, these fabrics are easily available in every Indian household. There is 45°of triangular mount at the top and bottom of the mask to provide support at the nose and at the bottom of the mouth. It also has a large inner pocket ($9/10^{th}$ of the size of outer layer).

Another highlight of the mask is the uniquely designed activated carbon filter bed safely placed inside the inner pocket of the mask. Use of activated carbon in making the mask makes it dual efficient. Each activated carbon bed is made up by spreading and pressing the activated carbon granules on the paper towel made up of cellulose fibres. Cellulose fibre is an obvious choice because it has high absorption capacity. It is also eco-friendly and cost effective. Both carbon granules and cellulose fibres are easily available in Indian market. Use of activated carbon filter bed can provide protection to mask wearer as good as N95 face mask. A N95 face mask is designed to filter up to 95% of pollutants of less than 0.3 microns from the air (U.S. Department of Health and Services, 2018).

2. Testing and final design of the mask

The design of the mask was finalized after surveying different mask available in market and after reviewing the process of air purification. The selection of jute-cotton fabric and paper towel was done after trying many variants of fabric. Various designs made up of elliptical, rectangular and circular shapes were tried out before finalizing the current design. Quantity and quality of activated carbon used in the mask was also standardized after due deliberations. Each trial mask was evaluated on the parameters of preparation, effectiveness against pollution, safety and comfort. Initially activated carbon of granule form was pasted using adhesive on the paper towel but it made the carbon bed hard and uncomfortable. In initial trials, activated charcoal molecules of different quantities varying from 20mg to 5mg were used. The first prototype for pilot testing was developed after many iterations. The mask of four different sizes were prepared and tested on a sample of 65 people of different age groups. Table II summarizes the distribution of sample participants:

Table II: Sample details

Age (years)	Number
2-5	4
6-12	12
12-18	25
18 and above	24

The testing was done for the effectiveness of the mask against air pollution, easy on breathing and level of comfort in wearing the mask. The prevention of air pollution was assessed by measuring the oxygen saturation level using digital oximeter for one hour on adult sample (18 years and above). Detailed questionnaire was used and semi-structured interviews were conducted on the people above 10 years. Below is the analysis of the data collected during pilot testing:

a) Analysis of Oxygen Saturation level

All the participants were briefed about the making and working of the mask before asking them to wear the mask. They were made comfortable and were asked to wear the mask. Time was noted for each participant and level of oxygen saturation for each participant was noted at the time of wearing the mask. It was again noted after one hour. Participants were asked to wear the mask without any help. They were asked to continue their regular work after wearing the mask. Below is the range distribution of the level of Oxygen Saturation:

- Range of Oxygen saturation level before using mask: 82 - 98% per hour
- Range of Oxygen saturation level after using mask for one hour: 96 –99% per hour
- An average increase in the Oxygen saturation level is: 7.5% per hour

b) Analysis of Questionnaire

The questionnaire consisted of seven questions about the comfort level and easy to wear ability of the mask. Small informal discussions were also carried with the participants to support the responses. The table III summarizes the responses of the respondents.

Table III: Responses of the Questionnaire

Questions	Remarks
Is this mask made up of comfortable fabric?	98% people in survey thinks that this mask is mate of comfortable fabric.
Is this mask properly fits your face?	Mask is fitted properly during survey
Did the long duration use of this mask caused you any breathing difficulty?	No breathing difficulty is reported in survey
Did the prolonged use of this mask lead you to any allergic reactions?	No allergic reaction is reported in survey
Did the prolonged use of this mask lead you to any chronic pain?	No complains of chronic pain encountered during survey
What features of this mask do you appreciate the most?	98% people appreciated its Design, look, style and comfortable fabric
Do you found any difference between pollution mask available in the market and this (eco-friendly activated carbon powered) mask?	They didn't find any difference between this (eco-friendly activated carbon powered) mask and the pollution mask available in the market.
	98% participants appreciated the design. fitting and anti-pollutant properties of the mask.

After the pilot testing and reviewing the responses of the sample, the mask prototype was customized into three different sizes. Figure II presents the coral drawing of the final design of the mask and Table IV summarizes the measurements of three different sizes of the mask:

Table IV: Final sizes of the mask

Size of Eco-friendly Air Purifier Face Mask	Measurements (in inches)	Age group
Small (Type III)	5 x 3 x 1.5	Up to 5 yrs
Medium (Type-II)	6×4×2	6 -12 yrs
Large (Type-III)	7 x 4 x 2	13 –18 yrs

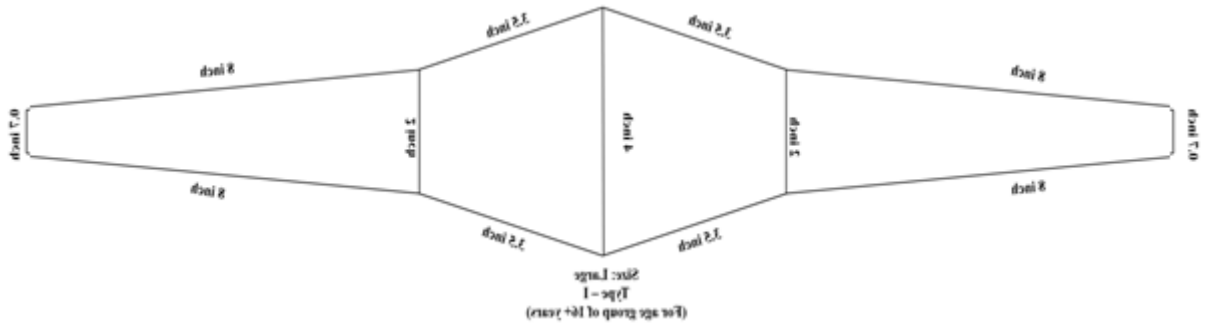

Figure II: Final design of the mask

Process of making activated carbon (charcoal) bed

One of the maor highlights of the mask is the inserted activated carbon beds which are replacable. The design of the carbon bed was finalized after multiple trials and suitability of the material for the outer cover, quality and quanitityof the activated carbon to be used, a Material for the surface of the bed = polypropylene fibre

Size of the mask= $3/5^{th}$ of the mask measurement

Lab graded activated carbon = 45Gms

Steps:

1) Two layers of spun polypropylene fibreof appropriate mask dimension is sprayed with water to make its surface wet.
2) 45 Gms of activated charcoal is spread properly over it.
3) Place the layers on each other.
4) Press it using both hands all through.
5) Cross stich on the entire surface to give it a nice padded shape.
6) Place the carbon bed into the inside pocket of the mask.

Figure III depicts the final design of the activated carbon bed.

Figure III: Activated carbon (charcoal) bed

Mask is further supported by the elastic band/ cotton belt with Velcro strap to be easily tied up at the back of the head. It gives protection to mouth, nose and ears. The three layer protection air purification mask has a very low making cost. The actual cost of making one mask is less than 10 Indian rupees. It can be reduced further on bulk production. It is accompanied by an easy to use manual which describes the process of making the mask at home. It is washable, reusable and can be used for long time just by changing the activated carbon bed. It empowers people to take responsibility of their breathing needs. It can be the beginning of a mass movement;*Safe breathing is my right.*

3. Acknowledgment

I sincerely acknowledge the guidance of my mentor Dr. P. Lele, In charge Atal Tinkering Lab, Springdales School, Pusa Road. I am grateful to my school for encouraging me towards such scientific endeavors.

References

[1] Air Quality Data, Central Pollution Central Board, Government of India. (n.d.). Retrieved from http://cpcb.nic.in/.
[2] LiqingLi , Zheng Sun , Hailong Li & Tim C. Keener (2012) Effects of activated carbon surface properties on the adsorption of volatile organic compounds, Journal of the Air & Waste Management Association, 62:10, 1196-1202, Retrieved from https://doi.org/10.1080/10962247.2012.700633.
[3] U.S. Food & Drug Administraor under U.S. Department of Health and Service. Masks and respirator. Retrieved from https://www.fda.gov/medicaldevices/productsandmedicalprocedures/
[4] Kejriwal, A. (2017). Tweeted comment, Retrieved from https://twitter.com/arvindkejriwal/status/.