Journal of Energy Research and Environmental Technology (JERET)
p-ISSN: 2394-1561; e-ISSN: 2394-157X; Volume 4, Issue 3; July-September, 2017; pp. 253-256

http://www.krishisanskriti.org/Publication.html

Activated Carbon Based Indoor Air Purifier

Sumit Dhama[1], Maham Malik[2], Anamika Paul[*3] and Sanjni Mehrotra[4]

[1,2,3,4]Galgotias University
E-mail: [1]dhamasumit26@gmail.com, [2]mahammalik.amu@gmail.com
[3]anamika.sikdar@gmail.com, [4]sanjni.mehrotra12@gmail.com

Abstract—*The atmospheric particulate matters are microscopic solid or liquid matter suspended in air. The particulate matters are either directly emitted into the atmosphere or are formed by reactions once in the atmosphere. These particulate matters have a strong impact on climate, vegetation and human health. It has been observed that with the increase in the industrial and other activities such as constructions, forest fires, etc., there is a tremendous increase of the particulate matter in the atmosphere which has consequently adversely affected the indoor air quality. This decrease in the indoor air quality has led to rise in the popularity of indoor air purifiers. As a result, demand for air purifiers is having an exponential rise leading to the cost of presently available indoor air purifiers also increasing at an alarming rate. This has left the general public being unable to afford a cost effective indoor air purifier for clean indoor air.*

In order to deal with problems discussed above, an inexpensive and reliable air purifier was designed, which uses carbon based adsorbent and cloth fibers [1]. The activated carbon strips the air of volatile organic compounds. Activated carbon was used because of its high porosity which captures the contaminants and also it is odor efficient. Due to its porous structure when certain impurities pass to the carbon surface it gets trapped and adsorbed to it by chemical attraction due to having countless bounding sites on its surface. The natural and synthetic cloth fibers are used for removing particulate matter. The air purifier has been tested and can be used for upto 7 hours..

Keywords*: Purifier, Indoor air, PM, Activated carbon.*

1. INTRODUCTION

People living in polluted cities, work sites & industrial regions face high exposure of hazardous airborne particles such as SO_2, H_2S, NOx, CO & dust. This increases the risk of health problems like asthma, nausea, irritated eyes, allergy, infections, etc. [2]. It is well perceived that there is a permissible limit of the gaseous compounds above which they are generally toxic & some are even hazardous. Outdoor air pollution has given rise to intoxication of indoor air, which has increased the risk on the health of people. According to US EPA (Environmental Protection Agency) 2015 data, indoor air pollution is ranked among the top five environmental health risks[3]. Therefore eliminating these gaseous pollutants from the surrounding will ensure human health.

To eradicate this problem many residential air cleaning devices are proposed. But generally due to its high cost and people being unaware of it, purification of indoor air has not been taken seriously as it should be.

A portable, light weighed, efficient & affordable air purifier to improve the indoor air quality by removing pollutants from indoor air is designed and constructed in the present study. This air purifier consists of small pellets of activated carbon which adsorbs the airborne particles onto its surface[4].

Activated carbon is currently the research focus for purification of air and water as it emerging as an adsorbent of choice because of its stability, wide range of application, resistance against oxidation (when infiltrated with silicon dioxide) [5]. Coated activated carbon was found to be effective for the removal of NO_2 and HONO present in indoor air. Commercially available activated carbon in the presence of Ozone, has been found to be efficient in removing volatile organic compounds, such as alkanes, aromatic hydrocarbons, alcohols, ketones, halocarbons, aldehydes, esters, terpenes, ethers, glycols and nitrogenized compounds, from indoor and outdoor air [6].

The activated carbon based air purifier is related to the combination of the proposed devices under the study of EPA which is gas phase air filter which falls under category of Portable air cleansers. It is convenient to use and travel with it. It is comprised of mostly easily available products thus making it not an expensive product. The parts of the air purifier has been designed so that they can be easily dismantled, cleaned and the used activated carbon can be either regenerated or replaced with a fresh batch.

In the present model, to increase the potential of air purification, a layer of cotton was added to maximize the trapping of gaseous pollutants. These adsorbents are placed in the casings of hardware cloth which forms the skeleton of our air purifier.

2. MATERIALS OF CONSTRUCTION

The following materials were used for the construction of the activated carbon based indoor air purifier

- Activated carbon pellets (Fig 1) - 500gm
- Steel hardware cloth (Fig 2) - 1 meter
- Cotton width 0.01 meter
- Muslin cloth- 0.5 meter
- Exhaust fan- 12V, 1A
- Adaptor- 12V, 1A
- Plastic duct cap
- Cardboards
- Scissors & tapes

Figure 1: Activated Carbon Pellets

Figure 2: Synthetic hardware cloth

Activated Carbon Pellets

Activated carbon is a good adsorbing agent due to its high porosity and high surface area which gives countless bounding sites for the trapping of the molecules. It is also inexpensive & easily available in many shapes and in granulated form. Most recent developments for the use of activated carbon include sheeting of the adsorbent so as to gain maximum surface area.

Steel Cloth

Steel used as mesh cloth is an alloy of iron and other elements, primarily carbon. It has high tensile strength & high durability. It is easy to handle & can withstand heavy weight. The light weight of steel and its resistance to corrosion made it the material of choice. Also it is easily available in the market.

Cotton

Cotton is a good adsorbent of large airborne particles. It is light weight and is easy to mend in the desirable shape. It works as a natural fibre filter because of its high trapping efficiency. Cotton has a pore size of about 4.5 µm while the air particulates generally have diameter of 2.5 µm. Thus cotton enables the trapping the harmful air particulates. Cotton being a major agricultural crop, has been cultivated in various parts of the India and thus have higher availability in the Indian market at an economic price.

Exhaust Fan

Exhaust fan is used for giving proper suction which helps in maintaining appropriate air flow inside purifier. This allows the purifier to be operated at steady working condition throughout the period of operation. In the present set up, DC 5V fan which is used for cooling of laptops is used. It is light weight, inexpensive, easily available & requires minimal energy for its functioning.

Muslin Cloth

Muslin cloth has fine mesh size which doesn't allow the activated carbon material to drop out from the casing. It provides filtration of fine airborne particles and also helps in trapping particulate matter. Muslin cloth has maximum pore size of 2 mm so it can trap particulates & airborne particles of variable sizes. It is easily available & costs Rs 150 per meter.

3. CONSTRUCTION OF AIR PURIFIER

The final design and subsequent construction of the activated carbon indoor air purifier is done by trying out a few designs and finalizing the most optimum design which was then used for the construction of the working model.

In the initial stage of Activated Carbon Based Air Purifier 1 m hardware cloth of mesh size 1mm was used to construct the skeleton of our model. Three cylinders of different diameters i.e. 0.06m, 0.07m & 0.09m, respectively and of height 0.39m, 0.34m & 0.38m were constructed. These cylinders were attached with each other with plastic duct cap. Table 1 presents the dimensions of the air purifier.

Table 1: Design Dimensions

Cylinder	Height(m)	Diameter(m)
1	0.39	0.06
2	0.34	0.07
3	0.38	0.09

Figure 3: Indoor Air Purifier Setup

The core cylinder is kept at maximum height and lowest diameter i.e. 0.39m & 0.06m. The height of the middle cylinder was kept at 0.34m & diameter is 0.07m. The height of outermost cylinder is 0.38m & of maximum diameter 0.08m. Figure 3 shows the constructed air purifier.

The centre core of the system is vacant & exhaust fan at one end is placed attached to the innermost cylinder, so that air can easily flow through this area. A thin layer of cotton is packed between 1st& 2nd cylinders. The pellets of activated carbon were filled between 2nd & 3rd cylinders. Finally, the outer cylinder was wrapped with muslin cloth to prevent the small pellets of activated carbon from falling out of the hardware cloth.

4. ESTIMATION OF AIR FLOW

It is necessary to estimate the flowrate of air flowing through the air purifier as it helps in sizing the equipment according to the size of the room. The following design parameters were used to calculate the flowrate of air passing through the air purifier.

Air change rate per hour (ACR)

ACR= (CFM*60)/air flow rate
OR volume of room [7]

Where **CFM** is air flow through the room (Cubic Feet per Minute) [8]

Power Required

Power required for operating the air purifier is calculated as a product of voltage and current input (V*I).

5. OPERATION OF THE AIR PURIFIER

The air purifier works on the principle of change in pressure. Suction is created inside the core cylinder of hardware cloth which is empty. This suction helps in providing pressure difference between core & surrounding that helps in the movement of polluted air through it. Subsequently, the air passes through the spacing between 1st& 2nd cylinder which is filled with a cotton layer of width 0.01m. The cotton layer works as an adsorbent for sufficiently large size airborne particles such as dust, pollen particles, etc. and these get trapped within the bulk of the cotton layer. Due to this reason, weight and color of the cotton layer changes after some time.

Finally, the air passes through the spacing between 2nd & 3rd cylinders which is filled with pellets of activated carbon. The pallets are arranged in a systematic manner so that the contact area between gases and activated carbon gets maximized. These pellets adsorb the gaseous pollutants onto its surface which are not adsorbed in the upper layer resulting in purified air. The purified air is passed through the muslin cloth before releasing it to the surrounding.

6. EXPERIMENTAL METHODOLOGY

The air purifier was designed and constructed as stated in the previous section. To test the working of the purifier, a test room measuring approximately $11m^3$ by volume was selected. The initial weight of the packing material was measured using a digital weighing machine. All the possible ventilation systems in the room were sealed.

To test the purifier the room was filled with smoke releasing from burning of neem leaves. For this, 200gm of neem leaves was weighed & burnt in a washbowl in the closed room. The neem leaves produced enormous amount of smoke in the room. The smoke was irritating for the eyes and the air inside the room was not breathable. Also visibility in the room reduced drastically. There was also a very pungent burning smell in the room.

The air purifier was then placed in the center of the room and switched ON. It was observed that after a period of 2 hours the visibility had improved, there were no irritants present in the air and the odor of the neem leaves was also negligible. The final weight of the packing was the measured by digital weighing machine.

7. RESULTS AND DISCUSSIONS

The weight of the setup initially was 1.140 kg. After operating the equipment for 2hrs, the setup was again weighted. It was observed that there was considerable change in the weight of setup. The final weight of the setup was noted to be 1.143 kg, which results in an increase of change 0.003kg. For a small closed room, the change in the quality of air was considered substantial.

The change in the weight occurred due to adsorption and absorption of gases and fine solid particle on the activated carbon as well as on cotton. It was also observed that the visibility of the room increased after the equipment started operating. The air was breathable after an hour of operating the equipment. And there were less number of irritants in the room. The color of cotton layer inside the equipment also changed from white to pale yellow. The burning smell of the leaves also diminished.

8. CONCLUSIONS

After 2 hrs of operating of the air purifier it was observed that the weight of the purifier has significantly increased. This increase in the weight suggests that the air purifier has adsorbed the pollutants present in the environment in significant amounts. Additionally, the visibility increased and odour decreased noticeably.

9. RECOMMENDATIONS

The present project is only a preliminary in its study and further work will be required before a commercial version of the purifier can be finalized. Study needs to be conducted by replacing the activated carbon pellets with the activated carbon sheets which is expected to have more contact sites to improve the adsorption Also, a higher voltage exhaust fan can be installed to provide higher suction which in turn increases the adsorbing efficiency. Silicon coated activated carbon pellets can be tested for their efficiency as an air purifier as it provides adsorption of ionic elements thereby increasing the overall adsorption of particulate matters.

REFERENCES

[1] S. Gokhale, “Air Pollution Sampling and Analysis,” Laboratory manual., pp. 36-41, no. May, 2009.

[2] B. Curdts, M. Helmich, C. Pasel, D. Bathen, B. Atakan, and C. Pflitsch, “Upscaling the chemical vapor infiltration process of activated carbon with TMS,” *Phys. Procedia*, vol. 46, no. Eurocvd 19, pp. 248–254, 2013.

[3] David R, “Four Simple Steps for Sizing an Air Filter,” HVAC System Blogspot, November 2013.

[4] “Methods of Calculation of Minimum FreshAir Requirements,”Commonwealth of Australia, 2012

[5] X. Guardino, “Experimental evaluation of VOC removal efficiency of a coconut shell activated carbon filter for indoor air quality enhancement,” *Build. Environ.*, Volume 67, p. Pages 14–25,2013.

[6] A. Dutta, B. Deka, and P. P. Sahu, “Design and fabrication of silicon oxynitride based evanescent optical waveguide sensor for rapid detection of adulteration in petrol,” *Procedia Eng.*, vol. 64, pp. 195–204, 2013.

[7] I. B. Tertentu, M. Sen, and S. Grille, “Laboratory Fume Hoods Manual,” Public works and government services, Canada,vol. 3,pp. 10–18, 2013.

[8] “Air Pollution Emission Control Devices for Stationary Sources,” *Air Waste Manaement. Assoc.*, April, pp. 1–6, 2007.