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Removal of Carbon Compounds from Polluted Air Through Adsorption for Effective Air Purification Using Activated Carbon Filter

Ashlesha Ambhurkar [1], Esha Vargantiwar [2], Riya Jagadale [3], Mohd Faisal Khan [4], Simran Pothare [5]

Dr. Abhay Shende [6], Prof. Pravin Sahare [7]

[1,2,3,4,5] *Student, Department of Civil Engg, Priyadarshini J.L. College of Engg. Nandanvan, RTMNU, Nagpur , Maharashtra, India*

[6] *Principal of Priyadarshini J.L. College of Engg. Nandanvan, RTMNU, Nagpur, Maharashtra, India*

[7] *Asst. Prof, Department of Civil Engg, Priyadarshini J.L. College of Engg. Nandanvan, RTMNU, Nagpur, Maharashtra, India*

Abstract: We have created a working model in which we used the Activated Carbon Sheet, HEPA filter to purify the polluted air. This type of air filter can theoretically remove at least 99.97% of dust, pollen, mold, bacteria, and any airborne particles with a size of 0.3 microns (µm). The diameter specification of 0.3 microns corresponds to the worst case; the most penetrating particle size (MPPS). Particles that are larger or smaller are trapped with even higher efficiency. Using the worst case particle size results in the worst-case efficiency rating (i.e. 99.97% or better for all particle sizes). The air will enter the model then the filter will adsorb the pollutants and hence the pure air will come out through the exhaust fan.

Keywords: Air pollution, Activated Carbon filter, HEPA filter, CO2 pollutant, effects, techniques, etc.

1. INTRODUCTION

Air pollution is the contamination of the indoor or outdoor air by a range of gasses and solids that modify its natural characteristics. Key health harmful pollutants include particulate matter (PM2.5 and PM10) 1, carbon monoxide (CO), ozone (O3), carbon dioxide (CO2), sulfur dioxide and nitrogen oxides (NOx).

Air pollution is often not visible to the naked eye as the size of the pollutants are smaller than the human eye can detect. They can become visible in some situations for example in the form of sooty smoke from the open burning of crop residues or other waste, as well as from burning wood, coal, petrol and diesel fuels for cooking and heating, transport or power production. The fact that you cannot see the air pollution does not mean that it does not exist. Air pollution is the world's largest environmental threat to human health and one of the major preventable causes of death and disease. According to WHO, the ambient and household air pollution together account for 7 million premature deaths globally every year, making it more deadly than a combination of malaria, tuberculosis, and AIDS. In particular, an estimated 4.2 million people die prematurely around the world due to ambient air pollution, mostly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children. It disproportionately affects women, children, and the elderly in developing nations, who are frequently exposed to ambient and indoor air pollutions.

The World Bank has estimated that welfare losses (premature deaths) and productivity losses (lost labor) caused by air pollution cost the world economy over $8 trillion per year. Air quality is closely related to the Earth's climate and ecosystems globally. Many of the contributors of local air pollution are also sources of greenhouse emission i.e., burning of fossil fuel.

Activated carbon is a form of carbon processed to have small, low-volume pores that increase its surface area, making it highly effective for adsorption. The material can be derived from natural sources such as coconut shells, coal, wood, or peat, and is activated through physical or chemical processes. The high porosity and surface area of activated carbon enable it to trap gas molecules, including carbon compounds.

Activated carbon is a carbonaceous material that has been specially treated to enhance its ability to attract and remove other compounds from air and water. The goal of carbon activation is to increase its surface area (also referred to as a 'bed') to allow it to combat a greater

number of air pollutants. This results in the removal of these pollutants from your breathing air. Its bed structure is porous, making it capable of fixing itself to pollution particles and gases.

Activated carbon works by using a process called adsorption. This is when pollution particles stick to the outside of the carbon molecule. Carbon's increased surface area ('bed') as a result of the activation process provides more space to which pollutants can adhere. Thanks to activation, this newly enhanced surface area allows the activated carbon to trap more pollutants in its bed. The adsorption process only concerns the surface of the solid.

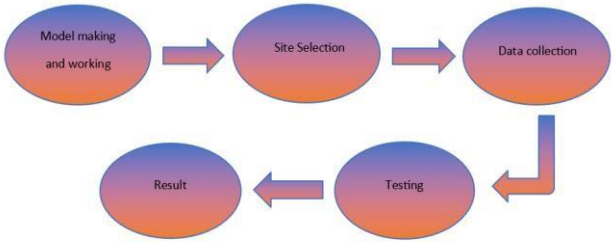
The activated carbon filters used in our products have a high density and high adsorption capacity. This enables them to clean the air of many chemical pollutant molecules and volatile organic compounds (VOCs).

Aim: The aim of research to remove carbon pollutants from the air by using activated carbon filter

Objective of Research Work:

1. To remove carbon compounds from the polluted air.
2. To reduce volatile compounds (VOCs).
3. To reduce unpleasant odors and other gaseous pollutants.
4. Filtering particulate matter.
5. Improving indoor air quality.

2. METHODOLOGY



FILTER UNIT PREPARATION

- Designed a rectangular box-type structure for filtration system.
- The size of box-type rectangular structure is 46cmx34cm.
- The 5 sides of the rectangular box covered by the plywood and in 1 side we used activated carbon sheet.
- The inner and outer frame structure of wood, which supported by the fine netting.
- The exhaust fan which is at the top, pulls or circulate the flow of air.

Materials and Components are used -

- Activated Carbon Sheet - Adsorption medium for pollutants
- Box Enclosure - The filtration system
- Openings - Allows air intake and exist
- Exhaust Fan - Creates air flow.
- Air Quality Meter - For measuring air quality before and after filtration

Design and Fabrication -

Conceptual Design

- Designed the air purifier model using **CAD software**.
- Dimensions and structural considerations.

Assembly Process

- Cutting and shaping the box enclosure.
- Constructed the casing using wood material.
- Mounting the exhaust fan to create suction.
- Placing activated carbon sheet in the airflow path.
- Securing the structure and sealing gaps to prevent air leakage.

Working Principle -

- Air is drawn into the purifier by the exhaust fan.
- After that the activated carbon sheet, which adsorbs the carbon compounds, neutralizing odors and harmful gases.
- The purified air released back into the room.

3. DATA COLLECTION

After every 15 min data have collected for 1 hours to see the Air Quality and pollutants of the room by AQI Detector.

Room Dimensions = (10*8.8*3) m

Time (Minutes)	Air Quality (AQI)	Particulate Matter 2.5 (PM 2.5) ((µg/m³))	Particulate Matter 10 (PM 10) ((µg/m³))	Carbon Monoxide (CO) (µg/m³)	Carbon Dioxide (CO2) (µg/m³)	Total Volatile Organic Compounds (TVOCs) (mg/m³)	Formaldehyde (HCHO) (mg/m³)
0 (Initial)	71	052	080	003	447	0.016	0.004
15	48	034	054	005	481	0.030	0.009
30	44	030	048	004	469	0.023	0.006
45	41	029	052	004	465	0.023	0.007
60 (Final)	40	030	054	004	466	0.023	0.007

4. RESULT

1. Clean Air Delivery Rate (CADR):

CADR= Room Volume * In (Initial AQI/Final AQI) / Time Taken

Room Volume = 10*8.8*3 = 264 m³

Initial AQI = 71; Final AQI = 40
Time Taken = 60 min
CADR = 264* In (71/40) / 60 = 2.524 m^3/min

2. Air changes per hour (ACH):
ACH = 60* CFM / Room Volume

CFM = Room Volume / Air change rate
Room Volume = 264 cubic meter * 35.3147 cubic feet = 9323.08 cubic feet
Air change rate = 15 min
CFM=9323.08/15 = 621.33

ACH = 60* 621.33 / 9323.08 = 3.99 air changes per hour

3. AQI Reduction Percentage
AQI Reduction Percentage
= (Initial AQI – Final AQI / Initial AQI) *100
= (71 – 40 /71) * 10
AQI Reduction Percentage = 43%

5. FUTURE SCOPE

In current model, only one side has an activated carbon sheet for adsorption. In future, the design can be upgraded by adding activated carbon and HEPA sheets to all four sides to increase the surface area for filtration and improving the air purifier's efficiency.
In future versions of our air filter, we can add a solar panel instead of electricity to run the exhaust fan. This will help us to save electricity and make the purifier work even in places where regular powers are not available. We can also add a rechargeable battery to store the solar energy, so the purifier can run at night.
Right now, our purifier is made using wood. It is strong and easy to build with, but it is also heavy in nature. In future, we can use lighter materials like plastics, aluminium or metal sheets. This will make the purifier easier to carry and also gives the better look and longer life.

6. CONCLUSIONS

In this project, we made a simple and low-cost air purifier using an activated carbon sheet and a HEPA filter. The box design with a fan helps pull air through the filters, cleaning out dust, bad smells, and harmful gases. The activated carbon removes gases and odors, while the HEPA filter catches small dust particles.
The purifier works well for small rooms and is easy to make. In the future, we can improve it by using lighter materials, adding smart features, or even running it on solar power. This project shows that affordable and effective air purifiers can be made to improve indoor air quality and health.

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