



Experimental Study of Four Stage Air Purifier

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ABSTRACT:

An air purifier is a device designed to improve the quality of the air in a room by removing contaminants, odors, and bacteria from the air. There are several types of air purifiers available in the market, but the 4-stage air purifier is the most effective. The 4-stage air purifier uses a combination of filters and UV-C light technology to purify the air in a room.

The first stage of a 4-stage air purifier is the pre-filter stage. During this stage, the air purifier pulls in air from the room and filters it from large particles such as dust, hair, and pet dander. The pre-filter stage plays a crucial role in prolonging the life of the other filters in the air purifier.

The second stage is the activated carbon filter stage. Here, the air passes through a filter made of activated carbon, which helps to remove odors, smoke, and volatile organic compounds (VOCs). The activated carbon filter can also help to remove some chemical pollutants from the air. This filter is effective against removing unpleasant smells and can neutralize harmful gases and chemicals, making the air much fresher and cleaner.

The third stage is the HEPA filter stage. In this stage, the air passes through a high-efficiency particulate air (HEPA) filter, which captures 99.97% of airborne particles as small as 0.3 microns. This includes pollen, mold spores, bacteria, and viruses. The HEPA filter is highly effective at capturing microscopic particles that can cause respiratory problems and other health issues.

The fourth and final stage is the UV-C light stage. In this stage, the air purifier uses ultraviolet-C (UV-C) light to kill bacteria, viruses, and other micro-organisms that may have passed through the other filters. The UV-C light is also effective against some mold and fungi.

Key words: HEPA Filter, Fine filter, Pre-filter, UV-C light.

INTRODUCTION:

Air purification is an important aspect of ensuring clean and healthy air in our homes and workplaces. Poor indoor air quality can have a negative impact on our health, causing allergies, asthma, respiratory problems, and other health issues. Air purifiers are designed to remove pollutants, particles, and other harmful substances from the air we breathe, making it safer and healthier to breathe.

There are many different types of air purifiers available on the market, each with its own set of features and capabilities. However, most air purifiers use a combination of filters, UV-C light, and other technologies to clean the air. A typical air purification process involves four stages: pre-filter, HEPA filter, activated carbon filter, and UV-C light.

The pre-filter is the first line of defence in an air purifier. It captures larger particles such as pet hair, dust, and other debris, preventing them from reaching the more advanced filters. This stage is especially important for prolonging the life of the other filters. The pre-filter can be washed or replaced as needed.

The HEPA filter is the most essential filter in an air purifier. It captures small particles such as pollen, smoke, and mold spores, which can cause allergies or asthma attacks. HEPA filters can trap up to 99.97% of particles that are 0.3 microns or larger. HEPA filters are usually made of dense mats of randomly arranged fibres, which are designed to trap particles as they pass through the filter.

The activated carbon filter is designed to capture odors, volatile organic compounds (VOCs), and other gaseous pollutants. This filter has a large surface area, which allows it to trap a wide variety of chemicals and fumes. Activated carbon filters work by adsorption, which is the process of capturing pollutants on the surface of the filter material. The UV-C light is an optional feature in some air purifiers. It is designed to kill bacteria and viruses that may be present in the air.

The UV-C light works by disrupting the DNA of these microorganisms, which makes them unable to reproduce and thus neutralizes them. However, not all air purifiers include this feature.

By combining these four stages of air purification, an air purifier can effectively remove a wide range of airborne contaminants and improve indoor air quality. It is important to note that different air purifiers may use different technologies or filters, but the general principles behind these four stages remain the same. When choosing an air purifier, it is important to consider factors such as room size, filter replacement frequency, noise level, and energy efficiency, among others. With the right air purifier, you can enjoy clean and healthy air in your home or workplace.

Problem Statement:

Indoor air pollution can be a major concern, especially for individuals who spend a significant amount of time indoors. Common indoor air pollutants include dust, pollen, pet dander, smoke, and volatile organic compounds (VOCs). These pollutants can cause a range of health problems, including allergies, respiratory issues, and headaches. To address these concerns, it's important to have an air purification system in place that can effectively remove these pollutants and improve indoor air quality.

A 4-stage air purification system can be an effective way to remove common indoor air pollutants. The system should be designed to be efficient, cost-effective, and easy to maintain. Each stage of the system should have a specific function to ensure that all pollutants are effectively removed from the air. Here are the four stages that should be included in an effective air purification system:

- **Stage 1: Pre-Filter**

The first stage of the air purification system should include a pre-filter that captures larger particles, such as dust and pet hair. This stage helps to extend the life of the other filters in the system by preventing them from getting clogged with larger particles. Pre-filters can be easily cleaned or replaced, making this stage of the system easy to maintain.

- **Stage 2: HEPA Filter**

HEPA Filter The second stage of the system should include a HEPA filter that captures smaller particles, such as pollen and pet dander. HEPA filters can capture particles as small as 0.3 microns with a 99.97% efficiency rate. HEPA filters are considered to be one of the most effective types of air filters and can greatly improve indoor air quality.

- **Stage 3: Activated Carbon Filter**

The third stage of the system should include an activated carbon filter that absorbs volatile organic compounds (VOCs) and other odors, such as smoke and cooking smells. Activated carbon filters work by adsorbing chemicals onto a porous surface. This stage of the system is especially important for individuals who are sensitive to chemical odors or who live in areas with high levels of air pollution.

- **Stage 4: UV-C Light**

The final stage of the system should include a UV-C light that kills bacteria and viruses that may be present in the air. UV-C light has been shown to be effective at killing a wide range of airborne pathogens, making it an important addition to any air purification system.

These four stages, the air purification system should be designed to be easily maintainable, with filters that can be easily replaced and a system that can be cleaned periodically. The system should also be designed to be energy-efficient, with low energy consumption and a low noise level. Finally, the system should be affordable, with a reasonable upfront cost and low ongoing maintenance costs. By following these guidelines, individuals can create an air purification system that effectively removes indoor air pollutants and improves overall indoor air quality.

OBJECTIVE:

Air pollution is a major concern in many parts of the world, and it can have serious health consequences. Poor air quality can exacerbate respiratory problems such as allergies, asthma, and chronic obstructive pulmonary disease (COPD), and it can also increase the risk of heart disease, stroke, and other illnesses. To address this issue, many people are turning to air purification systems to clean the air in their homes and workplaces.

A 4-stage air purification system is a popular type of air purifier that is designed to remove pollutants, allergens, and other harmful particles from the air. The system typically includes four stages: a pre-filter, an activated carbon filter, a HEPA filter, and a UV-C light.

The pre-filter is the first stage of the system, and its purpose is to capture large particles such as dust, hair, and pet dander. This helps to extend the life of the other filters by preventing larger particles from clogging the system.

The second stage of the system is the activated carbon filter. This filter is designed to remove odors, volatile organic compounds (VOCs), and other chemicals from the air. This is especially important for people with chemical sensitivities or those living in areas with high pollution.

The third stage of the system is the HEPA filter. This filter is a high-efficiency particulate air (HEPA) filter, which is designed to capture tiny particles such as pollen, mold spores, and bacteria. This is important for people with allergies or respiratory issues, as well as for anyone who wants to ensure that the air they breathe is as clean and healthy as possible.

The fourth and final stage of the system is the UV-C light. This light is designed to help kill bacteria and viruses that may be present in the air. This is especially important for people with weakened immune systems or those who are prone to infections.

The objective of a 4-stage air purification system is to provide clean, healthy air for people to breathe. It can be especially beneficial for those with allergies, asthma, or other respiratory issues, as well as for people living in areas with high pollution or chemical sensitivity. By removing pollutants, allergens, and other harmful particles from the air, these systems can help improve overall health and wellbeing.

MODIFICATION:

Air purifiers have become a popular choice for those looking to improve their indoor air quality, especially in areas with high levels of air pollution. However, one major factor that often comes into play when considering an air purifier is the cost. Many air purifiers available in the market can be quite expensive, making them unaffordable for the average person.

Furthermore, while air purifiers can help remove harmful pollutants and allergens from the air, some models may emit ozone gas, which can cause a variety of health problems. Breathing in ozone can result in chest pain, coughing, throat irritation, and can even impact lung function and damage lung tissue. Ozone exposure has also been linked to the development of asthma.

In light of these concerns, there is a need for an affordable air purifier that is not only effective in cleaning the air, but also does not emit any harmful gases such as ozone. The aim of this project is to develop an air purifier that addresses these concerns and is also affordable for the average person.

The primary focus of this air purifier will be to remove all dangerous elements from the air without emitting any ozone gas. In addition, the device will be designed to operate silently, addressing another common issue with air purifiers that can be noisy and disruptive.

By creating an air purifier that is both effective and affordable, this project aims to provide a solution for individuals and families who are looking to improve their indoor air quality without breaking the bank. With a focus on safety and affordability, this air purifier has the potential to make a positive impact on the lives of many people.

ADVANTAGES:

Air purification is the process of removing harmful pollutants and contaminants from the air. A 4-stage air purification system is a type of air purifier that uses four stages of filtration to clean the air. Here are some advantages of a 4-stage air purification system:

- Improved air quality: The four stages of filtration in a 4-stage air purification system work together to effectively remove a wide range of pollutants from the air, such as dust, pollen, smoke, mold, and bacteria.
- Improve air quality and help to make a healthier environment.
- Allergen reduction: The system's HEPA filter captures and removes allergens, such as pet dander, pollen, and dust mites, which can cause allergic reactions and respiratory problems. This is especially beneficial for people with allergies or asthma.
- Odor elimination: A 4-stage air purification system often includes an activated carbon filter, which effectively removes unpleasant odors and volatile organic compounds (VOCs) from the air. This results in fresher and more pleasant-smelling air.
- Protection from harmful particles: A 4-stage air purification system can effectively remove harmful particles, such as smoke and volatile organic compounds (VOCs), which causes many serious health problems after some time. This makes it an effective way to protect us and our family from harmful pollutants in the air.

DISADVANTAGES:

While 4-stage air purification systems have many benefits, there are a few potential disadvantages to consider:

- Cost: 4-stage air purifiers tend to be more expensive than basic models, due to the additional filtration stages and features. This can make them less accessible for some consumers.
- Energy Consumption: As a 4-stage air purifier has multiple filters and fans, it may consume more energy than a basic air purifier. This can lead to higher energy bills, especially if the unit is used frequently.
- Noise: Some 4-stage air purifiers can be noisy, particularly when running on higher settings. This may be a consideration for people who are sensitive to noise or who need to use the purifier in a quiet environment.

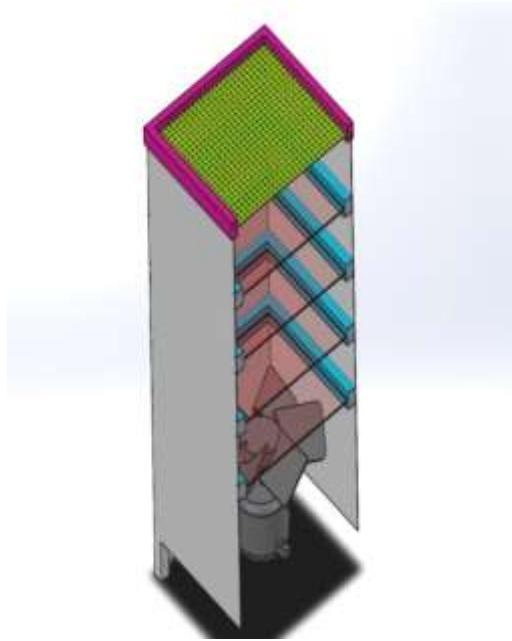
DESIGN:

Fig. Drafting

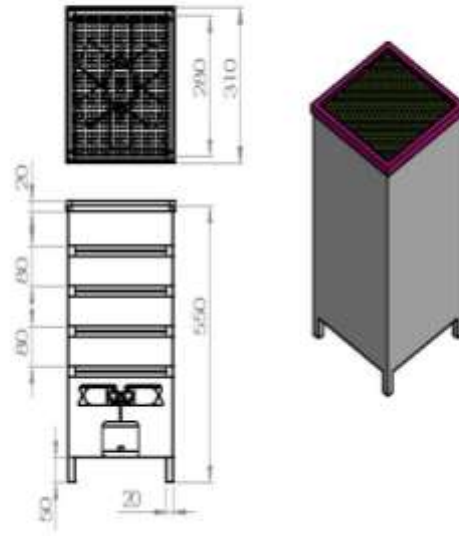


Fig. Cut section

WORKING OF AIR PURIFIER:

Shows the working principal of our air purifier. First when the fan is start it will start to pull the air from the room or nearby atmosphere. It will suck the air and push it to the filters. After that the air will flow through the filters and one by one the all impurities of air will be removed. At end at the other side of purifier we will get clean air. We have used HEPA in which HEPA filter and activated carbon removal is attached with each other.

Air pollution is a significant issue that affects many people and can lead to various health problems. Indoor air pollution can be particularly harmful, and air purifiers are a popular solution for combating this issue. Air purifier filters work by using fine sieves to filter out pollutants from the air. The finer sieve and small particles in the air can trap in filters. HEPA filters are considered the gold standard for air purifier filters. HEPA filter can trap 99.97% of airborne particles which have larger size more than 0.3 microns.

Microns are used to measurement and to quantify the size of particles present in the air. One micron is equal to the 1/25,400 of an inch. Particles are smaller in size, the human eyes cannot see them they must be bigger than 10 microns in size to see, that's why we can't see those dangerous pollutants like bacteria as well as viruses. HEPA filters are particularly effective at removing smaller allergens such as dust, smoke, chemicals, asbestos, pollen, and pet dander. In contrast, room air conditioner filters can only capture particles that are 10.0 microns or larger, making them less efficient at cleaning the air. Overall, HEPA filters are a reliable option for improving indoor air quality and promoting better respiratory health.

It is important to consider your need for air quality when choosing an air purifier. When we are looking to create a safe zone from seasonal air problems like allergies which are caused by pollen, dust also mites as well as mold spores, then a good HEPA or good HEPA or UV-C air purifier can be the best choice for our home. These air purifiers are highly effective to remove small particles from polluted the air, including allergens as well as bacteria. But when we just want to remove the pet dander and lint also household dust that causes breathing problems make breathing more difficult, for that we need to have more expensive air purifier may be suitable.

Air purifiers are a valuable tool in combating indoor air pollution. HEPA filters are the most effective filers to remove smaller particles than 0.3 microns from the surrounded air, making them the best choice for those with allergies and respiratory problems. However, it is important to consider our air quality needs when choosing an air purifier to ensure that you are getting the best product for your specific situation.

ACTUAL PHOTO:**CADR and ACH:**

CADR and ACH are two different measures of air purification efficiency that are commonly used to evaluate the performance of air purifiers. CADR stands for Clean Air Delivery Rate, and it refers to the amount of clean air that an air purifier can deliver into a room over a certain period of time. CADR is typically measured in cubic feet per minute (CFM) and is determined by testing the air purifier's ability to remove particles of various sizes from the air. A higher CADR indicates that the air purifier can clean the air in a room more quickly and effectively.

On the other hand, ACH stands for Air Changes per Hour, and it measures how many times the air in a room is completely exchanged with fresh air in an hour. A higher ACH indicates that the air in a room is being refreshed more frequently, which can help to reduce the concentration of indoor air pollutants. To calculate ACH, you need to know the volume of the room (in cubic feet) and the flow rate of the air purifier (in CFM). The formula for calculating ACH is given as:

$$\text{ACH} = (\text{flow rate} \times 60) / \text{room volume}$$

For instance, if you have an air purifier with a flow rate of 300 CFM and a room with a volume of 1,000 cubic feet, the ACH would be calculated as follows:

$$\text{ACH} = (300 \times 60) / 1,000$$

$$\text{ACH} = 18$$

This means that the air in the room is being completely exchanged with fresh air 18 times per hour. Both CADR and ACH are useful metrics to consider when selecting an air purifier, as they can give you an idea of how effective the air purifier is at removing indoor air pollutants from your living space.

ACH Calculation:

To calculate rating of ACH, we have to know the CADR of air purifier and the square feet area of the room where air purifier we have to use.

In India, air purifiers are usually rated in CADR (Clean Air Delivery Rate) which is measured in m³/hr. However, to convert this value to cubic feet per minute (CFM), we need to multiply it by 0.588 (1 m³/hr = 0.588 ft³/min).

The coverage area of an air purifier is usually given in square feet. If it is given in square meters, we can convert it to square feet by multiplying it by 10.76.

To calculate the volume of air that an air purifier can purify in an hour, we need to multiply the CADR in CFM by 60.

Next, we need to find the volume of the room in which the air purifier will be used. We can calculate this by multiplying the room's area in square feet by the height of the room. In India, the typical floor height is 9 feet.

To find the ACH (Air Changes per Hour) rating of the air purifier, we need to divide the volume of air delivered by the air purifier in an hour by the volume of the room.

Let us take an example to understand this better. Suppose we have an air purifier with a CADR of 300 m³/hr that will be used in a room with an area of 250 square feet. We can calculate the CADR in CFM as follows:

$$\text{CADR} = 300 \times 0.588 = 176.4 \text{ CFM.}$$

The volume of air changed in an hour is calculated as:

$$176.4 \times 60 = 10,584 \text{ CFM.}$$

Assuming the room height is 9 feet, we can calculate the volume of the room as:

$$250 \times 9 = 2250 \text{ cubic feet.}$$

Finally, we can calculate the ACH rating as follows:

$$\text{ACH} = \text{Air changed in an hour} / \text{Room volume} = 10,584 / 2250 = 4.70.$$

Suppose we plan to use the air purifier in a room that measures 10 x 12 feet with a height of 9 feet. The volume of the room is calculated as follows:

$$10 \times 12 \times 9 = 1080 \text{ cubic feet.}$$

To achieve an ACH of 4 in this room, we need to change the air in the room four times in an hour. This means that we need to purify $4 \times 1080 = 4320$ cubic feet of air per hour.

To convert this value to cubic meters per hour, we need to multiply it by 0.028 (1 ft³/hr = 0.028 cbm/hr). Therefore, the air changed per hour is $4320 \times 0.028 = 120$ m³/hr.

So, for a room with an area of 120 square feet, we need an air purifier with a CADR of 120 m³/hr. To convert this value to CFM, we can multiply it by 0.588: $120 \times 0.588 = 70.56$ CFM.

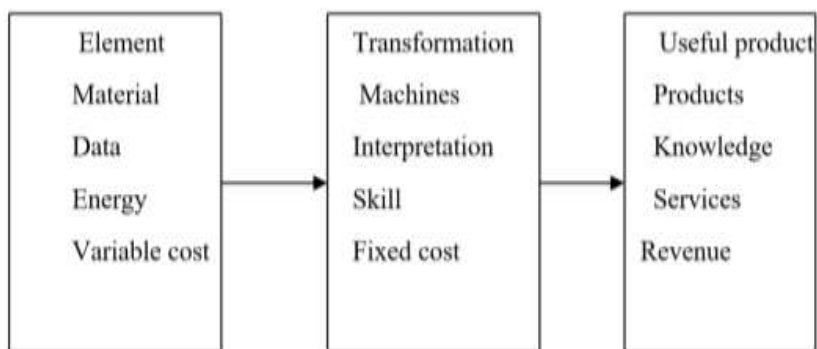
Therefore, we should select an air purifier with a fan that has an air velocity greater than 70 CFM for a room size of 11x10x10.

MANUFACTURING:

Manufacturing involves the process of transforming raw materials and other resources such as manpower, machines, and finished sub-components into finished products that are useful to consumers. This process typically involves various stages such as design, production planning, material sourcing, assembly, quality control, and packaging. The ultimate goal of manufacturing is to create products that meet customer needs while maximizing efficiency and profitability for the manufacturer.

The transformation process is shown below-

Input → conventional process → out put



It is the phase after the design. Hence referring to the those values we will plan

The various processes using the following machines: -

i) Universal Lathe:

The sheet metal body can be turned on a universal lathe to create cylindrical shapes, such as pipes or tubes, or to remove excess material from the body to create specific dimensions.

ii) Milling machine:

The milling machine can be used to create precise cuts and shapes on the sheet metal body. This can be useful for creating grooves, pockets,

iii) Grinding Machine:

A grinding machine can be used to smooth out rough edges or surfaces on the sheet metal body. This is important for creating a smooth, even surface for welding or for the final finish.

iv) Power saw:

The power saw can be used to cut the sheet metal body into specific shapes and sizes.

v) Drill machine: The drill machine can be used to create holes in the sheet metal body. This can be useful for fitting screws, bolts,

vi) Electric arc welding machine:

The electric arc welding machine can be used to join multiple sheet metal bodies together. This is important for creating a larger assembly.

COMPONENT : Sheet metal body

MATERIAL: C-45 mild steel

MATERIAL SPECIFICATION : 16 gauge thick and 8ftx4ft size

Table no1: list of manufacturing process for purifier body

Part no: 01		Material specification: body						
Part Name: outer body		Raw material size: 8ftx4ft sheet 16-gauge thickness						
SR. NO	Description of Operation		TOOLS			Time in minutes		
			Jigs and fixture	M/c tools	Cutting tools	Measuring instrument	Setting Time	M/c Time
1.	Cutting for length 300x300 mm	Shearing machine	Shear mc	Shear	Tape	12	5	17
2.	Grinding	None	Hand grinder	Grinding wheel	None	10		10
3.	Bending	Hand holded	Hand press	Bending die	Scale	10		10
4.	Welding	Hand held	Welding mc	Rod	Right angle	15	10	25
5.	Grinding	None	Hand grinder	Grinding wheel	Vernier	15	10	25
6.	Checking							

COMPONENT: Sheet metal body

MATERIAL: C-45 mild steel

MATERIAL SPECIFICATION : 16 gauge thick and 8ftx4ft size

Table no 2: list of manufacturing process for purifier body

Part no: 01			Material specification: body					
Part Name: outer body			Raw material size: 8ftx4ft sheet 16-gauge thickness					
SR. NO	Description of Operation		TOOLS			Time in minutes		
			Jigs and fixture	M/c tools	Cutting tools	Measuring instrument	Setting Time	M/c Time
1	Cutting for length 300x300 mm	Shearing machine	Shear mc	Shear	Tape	12	5	17
1	Grinding	None	Hand grinder	Grinding wheel	None	10		10
2	Bending	Hand holded	Hand press	Bending die	Scale	10		10
3	Welding	Hand held	Welding mc	Rod	Right angle	15	10	25
4	Grinding	None	Hand grinder	Grinding wheel	Vernier	15	10	25
5	Checking							

COMPONENT: Blower mounting**MATERIAL SPECIFICATION: Standard fan****MATERIAL: C-45 mild steel**

Table no.3: list of manufacturing process for frame body

Part no: 03			Material specification: mild steel C-45					
Part Name: blower mountings			Raw material size: 40 diam, 80 mm length					
SR. NO	Description of Operation		TOOLS			Time in minutes		
			Jigs and fixture	M/c tools	Cutting tools	Measuring instrument	Setting Time	M/c Time
1.	Holding job	Chop saw	Chop saw	18inch cutting wheel	Tape	5	1	5
2.	Cutting	Vice	Chop saw	Cutting wheel	-	10		10
3.	Drilling	-	Tail stock	Drill bit 4 mm	-	5	10	15
4.	Welding	Hand held	Welding mc	Rod	Right angle	15	10	25
5.	Grinding	None	Hand grinder	Grinding wheel	Vernier	15	10	25
6.	Checking							

CONCLUSION:

Air purification is a process that involves removing contaminants and pollutants from indoor air. This is important because poor indoor air quality can lead to a range of health issues, including allergies, asthma, and respiratory problems. One popular and effective option for air purification is a 4-stage system.

The first stage of a 4-stage air purification system typically involves a pre-filter. This filter is designed to capture larger particles such as hair, dust, and dirt. By removing these larger particles, the pre-filter helps to protect the other filters in the system and improve their overall effectiveness.

The second stage of a 4-stage air purification system often includes an activated carbon filter. This filter is designed to help remove odors and harmful gases from the air. Activated carbon is a highly porous material that can absorb a wide range of gases and chemicals, making it an effective way to improve indoor air quality.

The third stage of a 4-stage air purification system usually involves a HEPA filter. HEPA stands for High Efficiency Particulate Air, and these filters are designed to remove smaller particles from the air. This can include pollen, pet dander, and dust mites, which can all contribute to poor indoor air quality.

APPLICATION:

A 4-stage air purification system is an effective solution for improving indoor air quality in various settings.

In homes, a 4-stage air purifier can help to remove common allergens such as dust, pet dander, and pollen from the air, which can improve the quality of life for individuals with allergies or respiratory problems. The system can also remove other harmful pollutants like volatile organic compounds (VOCs), mold spores, and smoke, which can pose a health risk to individuals.

In office settings, air purifiers can help to reduce the spread of airborne illnesses by removing bacteria and viruses from the air. This is especially important in shared workspaces where individuals may be in close proximity to one another, making it easier for illnesses to spread.

Medical facilities such as hospitals and clinics can also benefit from air purifiers with a 4-stage filtration system. These systems can help to reduce the spread of infectious diseases by removing airborne pathogens from the air, helping to create a safer and healthier environment for patients and healthcare workers.

Schools can also benefit from the use of air purifiers. By removing pollutants from the air, air purifiers can help to improve indoor air quality in classrooms, which can have a positive impact on the health and concentration of students. This is particularly important for individuals with allergies or respiratory problems, who may be more susceptible to the negative effects of poor indoor air quality.

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