

PRIMAL RESEARCH IDEAS IN SCIENCE AND MANAGEMENT
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IDEA PROPOSAL APPLICATION

Automated Air purifier using AIOT: BREATHE PURE

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INTRODUCTION

Ever since Vehicle emissions and Industrialisation has hit the environment, the air has always been contaminated and harmful for living beings. While we have always been focusing on the outdoor air pollution and initiating measures to prevent it, the indoor air pollution, on the contrary, had been paving its way around and we haven't prioritized it highly.

According to recent research done by roughly 50 institutes, it has been found that the death ratio due to indoor air pollution is increasing at a rapid pace. Indoor air pollution from solid fuels accounted for 3.5 million deaths and 4.5% global daily-adjusted life year (DALY) in 2010; it also accounted for 16% particulate matter pollution. Several health issues due to indoor air pollution, include:

- **Asthma**: A lot of different things in the indoor environment can be asthma triggers and can affect people with asthma. It has been recognized that because Americans spend so much time indoors – over 90% of the day is spent at home, school, and/or work – it is important that people with asthma maintain healthy indoor environments that reduce these exposures to indoor triggers of asthma.

Not only can poor indoor air quality make the symptoms of someone who already has asthma worse, but it may also play a role in the development of asthma in more susceptible people, like small children. In addition, many people with asthma may be more sensitive to certain indoor air triggers than other people with asthma are. Nearly 3.6 million kids with asthma live in towns or cities with very high levels of ground-level ozone.

- **Lung Cancer**: Indoor air pollution is an important environmental risk factor for lung cancer in non-smoking Chinese women. Although the prevalence of cigarette smoking and second-hand smoking among women in Taiwan is low, but the incidence of lung adenocarcinoma among women in Taiwan is still rising. Incense burning and cooking were suspected to be important indoor air pollutants for lung cancer in Chinese women. Adenocarcinoma is the primary histological type of lung cancer associated with air pollution, especially among women who never smoke. Although the International Agency for Research on Cancer (IARC) classified outdoor air pollution and particulate matter (PM) from outdoor air pollution as carcinogenic to humans (IARC Group 1) in 2013, the evidence between indoor air pollution and lung cancer is still insufficient. Currently, no research has provided biological evidence of air pollutants in the lungs to support the association between indoor air pollution and lung cancer.

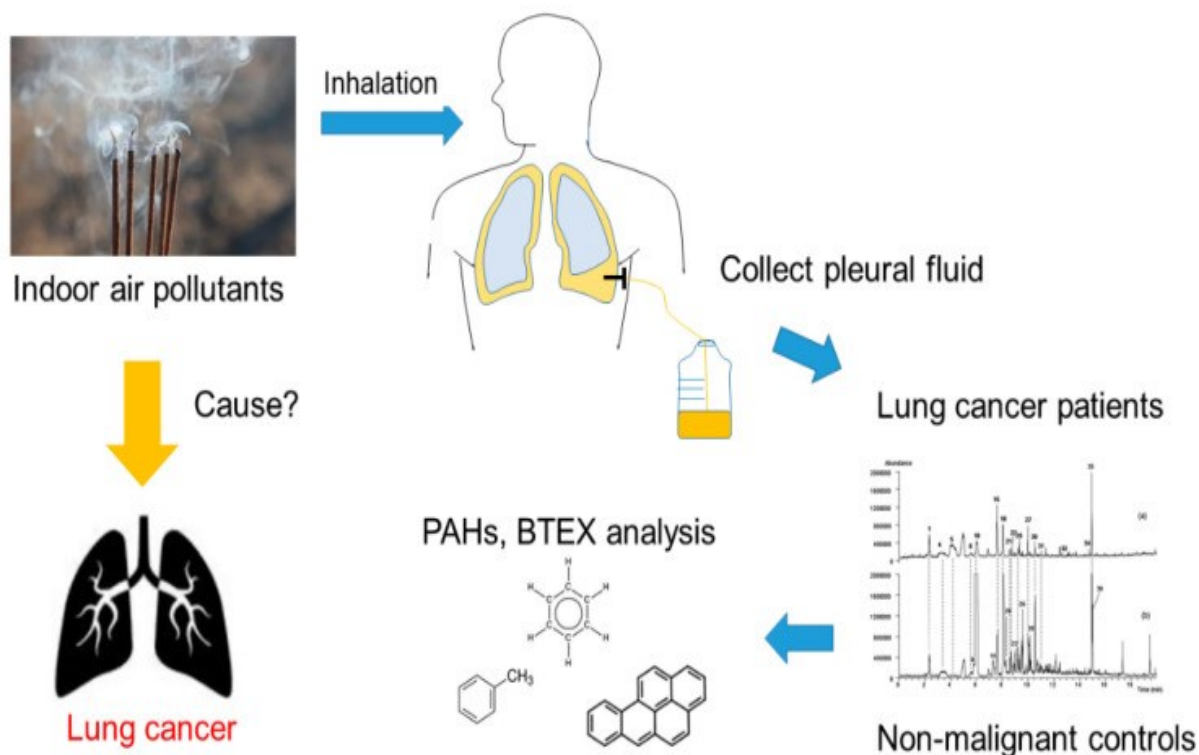


Figure 1: [Role of Indoor Air Pollution in causing Lung Cancer](#)

- **Ischaemic heart disease:** Each year, 3.2 million people die prematurely from illnesses attributable to the household air pollution caused by the incomplete combustion of solid fuels and kerosene used for cooking. Particulate matter and other pollutants in household air pollution inflame the airways and lungs, impair immune response, and reduce the oxygen-carrying capacity of the blood.

Among these 3.2 million deaths from household air pollution exposure:

Thirty-two percent are from ischaemic heart disease: 12% of all deaths due to ischaemic heart disease, accounting for over a million premature deaths annually, can be attributed to exposure to household air pollution.

METHODS

Dataset

The indoor air quality dataset comprises of more than 1 million records which highlights the death rates, causes and effects of indoor air pollution.

Household air pollution was responsible for an estimated 3.2 million deaths per year in 2020, including over 237 000 deaths of children under the age of 5.

It is essential to expand use of clean fuels and technologies to reduce household air pollution and protect health. These include solar, electricity, biogas, liquefied petroleum gas (LPG), natural gas, alcohol fuels, as well as biomass stoves that meet the emission targets in the WHO Guidelines.

AIR QUALITY INDEX

	AQI	PM 2.5 (ug/m3)	PM 10 (ug/m3)	VOC (ppm)	CO2 (ppm)	Formaldehyde (ppm)
Good	0-50	0 - 12	0 - 54	0 - 15	400 - 650	0 - 0.2
Moderate	51 - 100	12.1 - 35.4	55 - 154	16 - 25	651 - 1500	0.21 - 0.4
Unhealthy for sensitive groups	101 - 150	35.5 - 55.4	155 - 254	26 - 50	1501 - 2000	0.41 - 0.6
Unhealthy	151 - 200	55.5 - 150.4	255 - 354	51 - 75	2001 - 2500	0.61 - 0.8
Very Unhealthy	201 - 300	150.5 - 250.4	355 - 424	76 - 100	2501 - 5000	0.81 - 1
Hazardous	301 - 500	250.5 - 500	425 - 600	101 - 150	5001 - 15000	1.01 - 1.2

Figure 2: [Indoor Air Quality Standards](#)

Thus, keeping in mind, all the causes and effects of Indoor air pollution, the software and algorithm to be moulded should be built in such a way that it gives detailed information about the active pollutants in the air and rectifies the situation, simultaneously.

Algorithm, methods and Models

Purifying the air is an already existing form of preventing indoor air pollution, but keeping a track of what you are inhaling, is something no one has produced frequently. Furthermore, there are IEQ (Indoor Environmental Quality) software, created to calculate indoor air quality. IAQ measurements typically include temperature, humidity, draft, particles (PM2.5) and gases such as CO and CO₂. But that software only focuses on sensing and calculating the contaminated air. It does not prevent or solves the given crisis.

Therefore, the idea of the model and software, named BREATHE PURE has been taken into consideration, which not only detects the toxicity in air but also monitors as to when is it required to turn on the purifier and how much amount of the fresheners and purifying elements are to be released.

Another attracting feature of the model is that it helps in humidifying the environment by sprinkling water spray in the environment as and when dryness in the atmosphere is detected.

It also introduces fragrance into the air of interior spaces either as droplets which transition to vapor, or as the molecules of fragrance ingredients directly evaporating from a source. Both features can be turned on through the application as and when required.

Detection and purifying technology

The proposed idea is to keep track of pollutants in the environment, through an IEQ detector, which provides instructions to the built-in software and further, it controls the model, i.e., the air purifier and completes the process by switching it ON and purifying the air, accordingly.

The filtration process is carried out using a few technologies such as Pre-filter, Carbon filter and Formaldehyde filter.

- Pre-filters **capture the bigger pollutant particles, reducing the strain from the filter**. By doing this, they prevent the filter from clogging and increase its usable life. Pre-filters are cheaper and help in reducing the cost of replacing filters too often.
- Carbon air filters are the best medium to trap gas molecules. The filters are **used to remove gases using a bed of activated carbon**. They also help to remove volatile organic compounds that get released from the household products. They remove the odours from the air but are unable to remove mould and other substances.
- At present, most air purification equipment uses activated carbon for purification. Since activated carbon is a kind of porous carbon, **when gases such as formaldehyde pass through its internal pore structure, they will be physically adsorbed to achieve the purpose of purifying the air**.

The air toxicity rectification done through an in-built technology, HEPA, is used in portable air purifiers as it removes common airborne allergens. The **HEPA specification requires removal of at least 99.97% of 0.3 micrometres airborne pollutants.**

Most indoor air purification technologies come from industrial waste gas and related gas treatment technologies. The technology is divided into three main categories: dust removal technology, gas purification and sterilization technology.

Application software

Applications software is capable of dealing with user inputs and helps the user to complete the task.

The mobile application, linked to the technology inside the model, notifies the person through the application whether to start the model for purifying the air or not. The authoritative person gets to control the operation of turning the system ON/OFF.

As there would be a fixed threshold, when it reaches the system would automatically send an order to the technology to turn the model ON and conduct the purifying operation.

The person in authority also has accessibility to setting up a timer for the model, as to when it must start working and when to stop.

The application allows to decide how much of the purification is to be done.

There is in-app analysis of the records of how much of pollutants are present in the air. The manual option to turn the model ON/OFF is provided as well.

The mobile application also consists of an online shopping mart from where we can buy the required materials for the model, which include:

- The liquid container for chemicals
- The air freshener
- Water container
- The filter

The application has a user profile where the daily, weekly, and monthly analysis of how much the model has worked i.e., how much the air has been purified and humidified.

DESIGN / PROTOTYPE

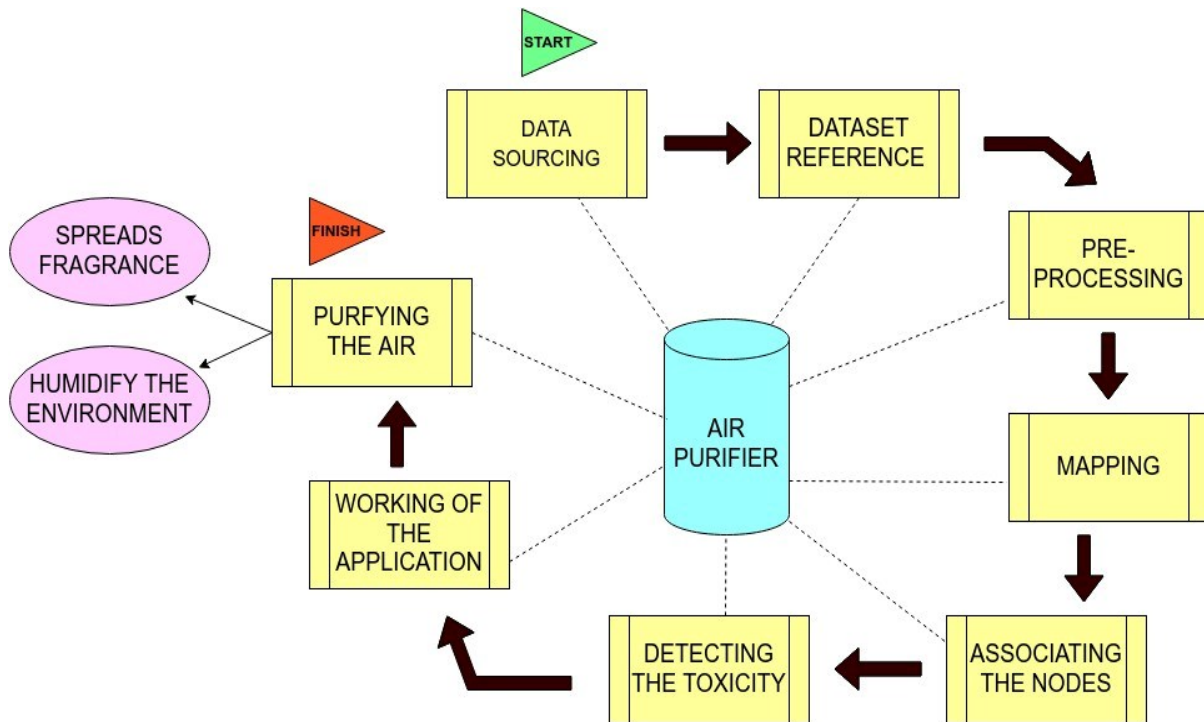


Figure 3: [Flow chart showing the process of the idea generation](#)

The above given diagram describes all the main steps performed by the model to increase the air quality.

As the image describes after detecting the toxicity by the model, it will pass information to the application, and it will eventually log the data according to time and scale for future reference.

1. **Data Sourcing:** The data extraction and integration from multiple internal and external sources was done as required in all the experiments to handle the workflow and achieve the desired results.
2. **Dataset Reference:** The dataset was taken from a website called 'Kaggle', created in the year 2013, which gives us over a million of records stating the death rates due to indoor air pollution and what all precautions and guidelines were set by WHO. The dataset's main highlights are the following few records given on the site:

- Access to clean fuels and technologies for cooking
- Death rate by source from indoor air pollution
- Household air pollution deaths by region
- Number of deaths by risk factor
- Population using solid fuels for cooking,

and many other records concerning indoor air quality are given in the dataset.

3. **Pre-processing:** The manipulation and extraction of data before mapping it is done in a way that it monitors the current state of the quality of air. To ensure that the monitored data is accurate or not on the basis of the used algorithm. To check whether the hardware is in proper working state or not, and whether the software is compatible with the hardware or not. To check whether the chemicals or filter used can purify the air and is not harmful for the living things present in the environment that is room, library, or any enclosed area.
4. **Mapping:** The mapping of the idea is done in such a way that it works only when the authorized person allows the notification received through the application. The person has access to operate the model manually also. A threshold is anyhow set to turn the model ON/OFF whenever the limit of the pollutants in the air exceeds. The person having the control of the application would be able to modify the model by buying new, improved parts or requirements for the model from the in-app store.
5. **Associating the nodes:** Bringing up all the aspects or states of the software and as well as hardware that we have discussed so far and finally implementing on the hardware to start functioning.
6. **Detecting the toxicity:** As soon as the hardware model detects the pollutants in the air, it carries a message to the software application, and it notifies the user to turn ON

the model. It also notifies about the level of pollutants in the air and whether the state of air is severe or moderate, depending on it the user will have to set the threshold.

7. Working of the Application: When the user receives the message through the application, the software is working on several things in the background which consists of the analysis of the working of the purifier, humidifier and the air freshener. The threshold set by the user requires a timer to work. The user can manually turn OFF the model through the application as well as automatically if they set the timer. The user also has the option to choose one of the three, Purifier, humidifier or the freshener, to work at a time.

There will be 2 modes of the software. One, The Neutral mode, in which the detection will be done on the regular basis depending on the atmosphere of the room.

Second, The Active mode, in which the pollutants which have reached higher levels will be purified on a higher level by increasing the amount of filtration, which can't be done by the Neutral mode.

Active mode will work as New Room Adaptation mode.

8. Purifying the air: In the end, after all the background working of the software, the model works and filters the air, resulting the air to be purified and humidified or freshened, if the user requires it. Depending on the two above given modes, the air will be purified by recognizing the type of environment present in the room.



RESULTS AND DISCUSSION

Detailed Analysis helps the user to keep a track of the environment around them and help them to inhale safe particles.

The discovery that Covid-19 spread through airborne particles and droplets showed just how important it is to ensure that we are in well-ventilated rooms with clean air.

As we spend most of our time inside, there is a rising focus on standards for indoor air quality. Poor air quality in the workplace is a silent killer of productivity, due to its effect on employee health and wellbeing. Many countries are also looking into defining air quality regulations. In the workplace alone, studies show poor indoor air quality can even reduce employee performance by 6%-9%.

How good indoor air quality benefits health in a workplace-

- **Reduced exposure to contaminants:** Indoor air pollution is linked to deaths caused by stroke, COPD, lung cancer, and others. By ensuring good IAQ in a building, there is a lesser chance of people being exposed to contaminants like Volatile Organic Compounds (VOCs). In turn, this reduces the risk of poor health and wellbeing.
- **Proven impact on performance:** Demonstrating low CO₂, PM 2.5, and toxic VOC levels can help ensure optimal performance. This offers employees greater peace of mind and will make them less likely to miss work due to health issues. According to a study, even minor improvements to the air quality inside buildings can have a huge impact on the decision-making performance of the staff.
- **Better employee health:** Bad air quality indoors may show itself in the form of fatigue, headaches, nausea, and other symptoms of discomfort. Increased and long-term exposure to air pollutants can lead to respiratory and cardiac diseases, among other health problems. By testing IAQ, one can ensure they provide a safe and clean workspace to their employees. This also improves employee morale, as they see that

the company cares for them. The result will be uninterrupted work and uncompromised performance – and consequently, a lower employee turnover rate.

- It gives an easy interface to control the model.

The prototype will be entirely controlled with an application installed in admin's smartphone. A unique identification number is assigned to the model. So that admin and accessed users can access the model and controlled all the functionalities with the ease of their smartphone. The model is also compatible with your smartphone, smart Google device, or Amazon Alexa so that you can control it remotely.

The model is self-capable of detecting, purifying, and providing its own products for the modification purpose.

Several health benefits provided by purifier function of the model are-

- Relieves symptoms of Asthma

According to the centres for Disease Control and Prevention, 1 in 12 people have asthma. People living with asthma have inflamed bronchial tubes. Pollutants such as pet dander, pollen, or dust mites irritate their airways, causing difficulty breathing.

The HEPA filters in model will help us to extract pollen, dust mites, and even capture smaller pathogens stimulating irritation in nasal passage.

- Model with activated carbon can cleanse these chemical contaminants, avoiding the risk of several health problems. A highly porous form of carbon is used in this carbon filtering method to trap chemicals like nitrogen dioxide and carbon monoxide, recycling fresh air back to the room.

- Some chemicals such as gasoline, benzene, and formaldehyde break down at room temperature causing an off-gassing odour. These chemicals, called Volatile organic compounds (VOCs), are commonly found in paints, aerosol sprays, upholstered furniture, or

air fresheners. Other NIH studies show low VOC levels in ambient air improves productivity and performance. One of the benefits of adding essence to the atmosphere will be, pleasant smells are scientifically proven to evoke positive, uplifting emotions and good memories.

- Reduces the Chances of Airborne Diseases

Pathogens causing common cold, and flu are floating around in air which will be captured by KEPA filters. Resulting in purified air.

Several health benefits provided by humidifier function of the model are-

- Reduces the spread of germs

A 2013 study found that if indoor humidity levels are less than 23%, influenza's infectivity rate — or its ability to infect others via respiratory air droplets — is between 70% and 77%. If indoor humidity is kept above 43%, the infectivity rate is much lower, between 14% and 22%

This is because the influenza virus survives better in drier conditions. A 2010 study evaluated the impact of a humidifier during winter months and found that a portable humidifier decreased influenza virus survival by 17.5% to 31.6%.

- Prevents dry skin

Humidifiers can counter this effect by increasing moisture in the air to help avoid discomfort and "get your skin glowing again

a small 2008 study in a Japanese hospital found that using a humidifier in winter boosted humidity from 32.8% to 43.9% and relieved dry and itchy skin symptoms among staff.

CONCLUSION

There is an increasing concern about air pollution levels both outdoors and indoors. According to the United States Environmental Protection Agency (EPA), indoor air can be five times as polluted as outdoor air. Since indoor air is not circulated as much as outside air, many airborne pollutants continue to thrive inside.

Air purifiers, specifically, BREATHE PURE model can refresh stale air, reducing the chances of health issues caused by indoor pollutants, which can trigger respiratory infections, neurological problems, or aggravate symptoms in asthma sufferers. Quality air purifiers eliminate several types of indoor air pollutants, keeping us healthy.

The comparison on how our model is better and upgraded the previous existing measures is given in the diagram below.

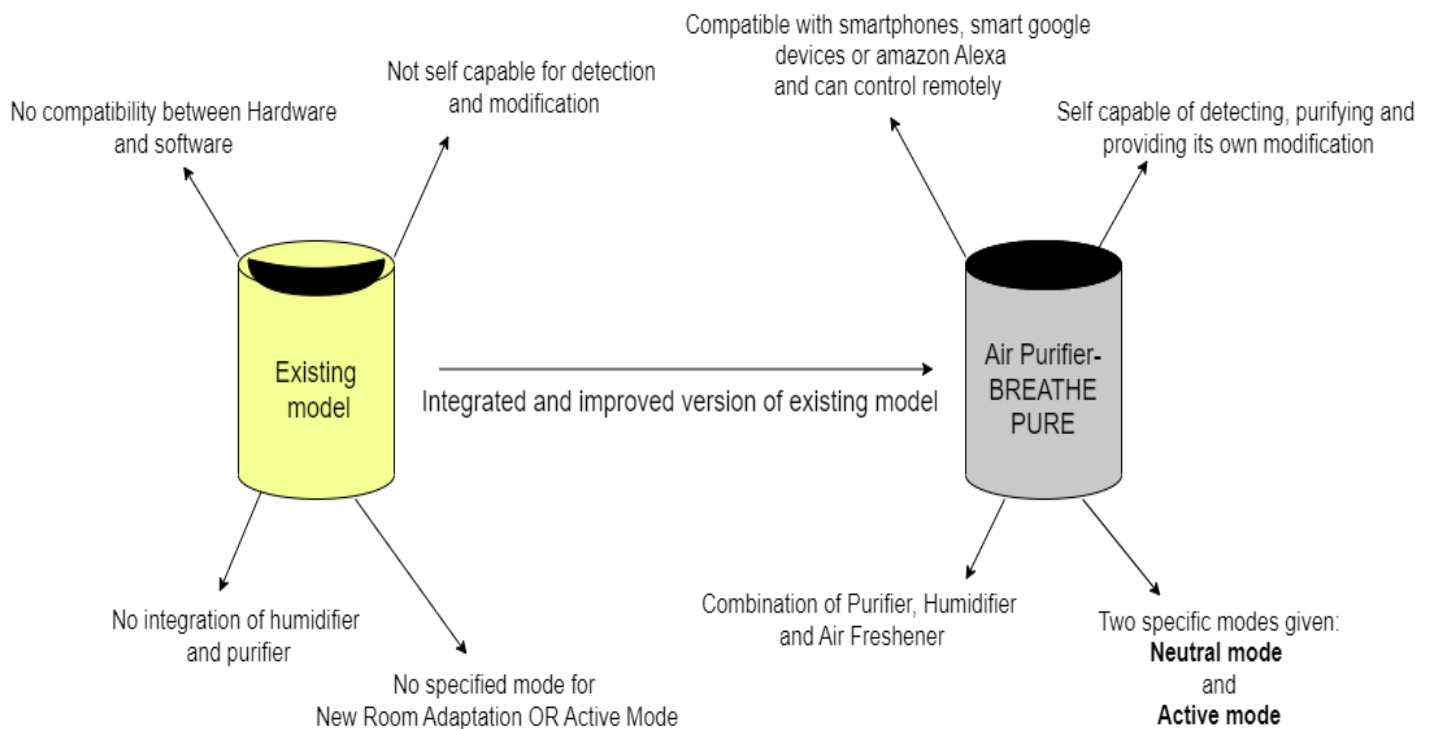


Figure 4: [Description of upgrades in the existing model](#)

To improve your indoor air quality, follow some other steps such as regular cleaning, growing indoor plants, and maintaining proper ventilation. The following steps can further improve your indoor air quality:

→Vacuums clean the floor and carpets at least once a week to prevent allergen build-up.

→Grow indoor plants for the bedroom. They act as natural air filters, diluting the carbon dioxide levels in the room.

→Use dehumidifiers to avert mould and mildew growth.

→When the air purifier is not in use, open windows for fresh air. If possible, allow cross-ventilation by opening windows at opposite ends of the room.

→Turn on the exhaust fans in the kitchen to dissipate smoke after cooking. The exhaust fan also dries up ambient air in the bathroom and laundry room, otherwise, humidity can lead to bacteria and allergen growth.

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