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Design & Development of an Air Purifier-A Review

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Abstract: In larger cities, the indoor air quality is decreasing drastically due to various factors such as growing population and industrialization that pollutes the air we breathe with contaminants like industrial dust, smog, pet dander and other harmful gases, particles from large number of vehicle traffic. It is known that indoor air is 5 times more polluted than outdoor air. The only solution to protect ourselves from this is to use air purifier inside the house with different filters to trap these impurities. An air purifier can also be used to ease annoyance for people suffer from allergies. However, the air purifiers available in the market are costly and make use of artificial filters that are not re-usable. Most of the time these filters end up in landfills and sometimes it become tedious job to replace these filters frequently. This paper reviews the use of renewable energy source low-cost air purifiers for indoor applications.

Keywords: Air Purifier, indoor, solar power, Natural filters

1. Introduction

1.1 Purpose of Air Purifier

Air purifiers can remove around 90% of the airborne pollutants in the indoor environment. Removal of these pollutants has several health benefits such as better sleep and increased life expectancy. According to several researches 1 in 12 people have asthma. People suffering from asthma have inflamed bronchial tubes. Pollutants such as pet dander, pollen, or dust mites irritate their airways, causing difficulty in breathing. Thus, increasing the risk of asthma attacks. Most of the air purifiers available in the market make use of HEPA filters, as it has the capability to trap these pollutants. HEPA filter consists of multi-layer meshes made up of fine fiberglass threads. The pollutants in the indoor air purifier are trapped in these meshes. Thus, we can enjoy clean and safe air.

Researches show that exposure to carbon monoxide and nitrogen dioxide increases the risk of dementia and Alzheimer's disease. These gases are usually from vehicles. We can't avoid these pollutants just by closing the doors or windows. Modern air purifiers also make use of activated carbon filter to cleanse these types of impurities, thus avoiding the risk of several health problems. A highly porous form of carbon is known as activated carbon, is used in this carbon filtering method to trap chemicals. Thus, recycling fresh air back to the room. Volatile organic compounds (VOCs) such as benzene, gasoline, and formaldehyde are present in the paints, aerosol sprays, air fresheners etc. The odour from VOCs can cause nausea, breathlessness, and even affect your cognitive functions. The air purifiers with carbon filter absorb entireOdour. Thus, making room fresh and clean.

Common airborne diseases such as common cold and flu are spread through tiny pathogens around. If one of the family members is infected by this airborne disease, it is natural that other family members will also get caught with these diseases as well. The reason this happens because everybody in the house is breathing the same air, which is infected with bacteria and viruses. To safeguard yourself and other family members from theses bacterial/viral infection, it is necessary to remove these tiny pathogens. If you live with elderly people, children, or anyone with lung related issue and with a weakened immune system, air purifiers with HEPA and carbon filters are must.

Allergies, common cold, and hay fever are triggered by Indoor allergens such as bacteria, fungi, and dust mites. The effects of these allergens are runny nose, lack of sleep, sore throat, watery eyes, disturbed sleep etc. Lack of adequate sleep affects the entire routine of the day. Runny nose can lost up to a week and it is a communicable disease spreading to other family members. To avoid these problems, it is necessary to use air purifiers with HEPA filters because they filter most of the allergens from indoor environment. This helps to improve sleep as well as keep the air clean and fresh.

There are few naturally occurring radioactive elements such as uranium in building materials which produces Radon gas. Radon gas is a colourless and odourless gas released from rocks, granites, soil etc. In order to protect ourselves from this harmful radon gas pollution, the use of air purifier is necessary. It is more effective to use air purifiers with HEPA filters and activated carbon filters, thus protecting ourselves effects of radon.

Since the use of asbestos were common in the year 1940 to 1960, people living in old house or those who work in old commercial buildings have been exposed to asbestos particles. As it ages, these buildings started shedding asbestos which combined with the air. Intake of this contaminated air would cause several lung diseases and it would increase the risk of lung cancer. Few symptoms of inhaling asbestos particles are loss of appetite, face & neck swelling, difficulty in swallowing. In order to get protection, air purifiers are must.

Several problems associated with Indoor pollution are cardiac, respiratory and neurological system problems. Household products release chemicals and gases that can accumulate in the lungs. In fact, the airborne particles are so small that they penetrate the blood-brain barrier, impacting your brain and cognitive functions. A good air purifier traps even the fine particles thereby improving the indoor air quality.

1.2 Motivation

According to survey conducted by WHO out of 1650 cities in the world, the capital territory of India, Delhi has the worst air quality. It affects Delhi and the other districts around. Air pollution has become the 5th largest killer in India and it is estimated to kill around two million people every year. In the survey conducted by WHO, chronic respiratory disease and asthma has become the major cause that made an increase in the death rate in India. About 2.2 million or 50 percent of the children of Delhi suffers from lung damage due to this.in order to overcome this problem, indoor air purifier is must.

Most of us find home as a place of peace and relaxing. Many a times, indoor air contains many micro-organisms and items in numerous amounts. It provides a diverse effect on the health when inhaled. These effects can be either flu or some allergy problems. With the modern technology, it's possible to clear this bacteria's, dust, smoke, mites etc by purifying the air with a bed of filters indoor. Allergens such as pollen from plants can cause a lot of discomfort particularly to those who suffer from asthma and other lung disorders. In order to ensure impurities free indoor air, air purifiers are required. Along with the comfort, air purifiers also provide protection. Air purifiers also help when the allergies are lethal due to hypersensitivity. Autoimmune diseases such as pulmonary fibrosis spring up not because of any pathogens or particles, but from the body attacking its own cells. This is also followed by pulmonary diseases such as tuberculosis and pneumonia. Here is where an air purifier becomes handy, by sifting out probable disease-causing Microbes.

1.3 Types of Air Purifier Available in Market

From research we get to know that, there are many Air purifiers which uses different filters to remove contaminants which is present in the air. After the pandemic the demandfor Air purifier has increased. Few air purifiers are listed below in Table 1.31

Table 1.31 Air Purifier available in market

Air Purifier Price List	**Price in India(Rs)**
HUL pureit H101 50W Air Purifier	7,199
Philips 20 Room Air Purifier	8,999
Airspa TMS16 Air Purifier	9,900
Conway Air Purifier	38,700
Philips Air Purifier	15,999
Eureka forbes Air Purifier	9,999
Philips Series 3000 AC3256/20 Room Air Purifier	25,499
Sharp Room Air Purifier	9,990
Laysko A504IN Air Purifier	9,999

Philips Series 2000 AC2887/20 Room Air Purifier	14500
Crompton Ionic Pro Air Purifier	15,599
Blueair Classic 405 Room Air Purifier	156644
Kent Aura Room Air Purifier	7250
Sharp Plasmacluster KC-850U Room Air Purifier	64,270
Amfah AMF-250AP Air Purifier	12,990
Panasonic Air Purifier	6,800

2. Literature Review

Rushikesh Kadam [1] worked on Solar Powered Air Purifier for improving Air Quality Index as shown in fig 2.1. Fabricated model consists of an Solar panel, Mq135 sensor, and air purifier filters i.e., HEPA filter & Activated carbon filter and other miscellaneous components for filtering the polluted air to survive. This model can capture carbon polluted particles, dust particles and smoke molecules. HEPA filter will be placed first in the model and then activated carbon filter is placed. Then the result of this model is 96 percent of clean air and can stand up to 15hrs out of 24hrs in solar energy.

As we seen this model runs in solar energy, the renewable source like sunlight is captured by the solar panel and that solar energy converts into electrical energy which helps to charge the 12v battery. And to convert the unstable current into stable they will be using solar charge controller. And the working principle is the fan which helps to circulate the air present in indoor, and the air will pass through the HEPA filter & activated carbon filter where impurities will be trapped like HEPA filter captures smoke & dust particles and activated carbon filter captures impure carbon molecules. From the help of 12v battery fan will be running. Mq135 sensor will take the reading of impurities present in indoor, and this all process will be controlled by microprocessor Arduino board.

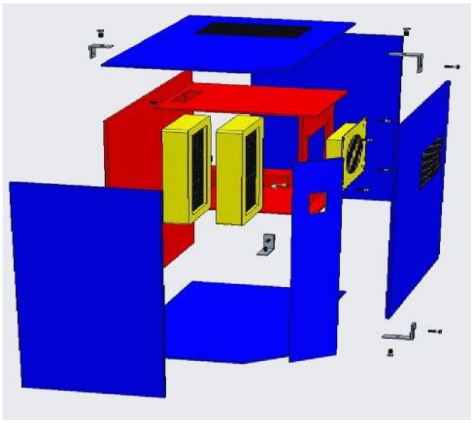

Fig 2.1 Air purifier for air quality index

Perumal [2] designed Solar Indoor Air-Purifier with Air Quality Monitor System as shown in fig 2.2. In this model it consists of Solar panel for energy supply), power-wall battery technology for storing power generated from the solar panel for later use), air purifier which has hybrid filtering system and air quality monitoring system to give the air composition data. A hybrid filtering system made up of three filtering sections, primary filtering section has pre-filter (HEPA filter). A pre-filter captures the largest particles before they reach the more expensive HEPA filter. Most of the particles in your air are large particles like dander and dust, not tiny ones like pollens and microbes. Even though HEPA filters have a large number of pleats to maximize their surface area, they can fill up quickly if larger particles are not pre-filtered out. Secondary filtering system consists of negative ion generator uses charged electrical surface or needles to generate electrically charged ions. Tertiary filtering section consists of an Ultra Violet filter, where Ultraviolet light UV technology is key to neutralizing viruses and bacteria that accumulate on air purifier air filters. Finally, a gravel activated carbon is

placed above the tertiary filter section were impurities like polluted gas which contains hazardous carbon polluted gas captured and leaves out the fresh air.

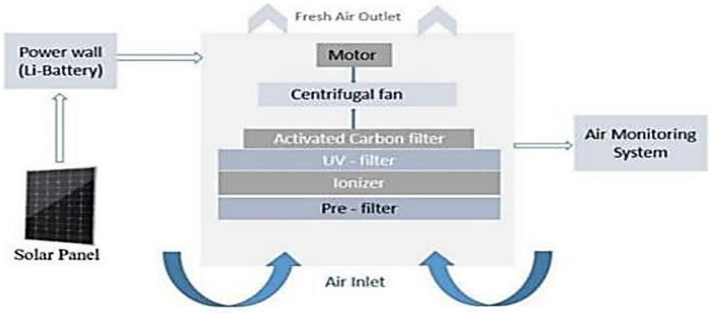

Fig 2.2 Solar powered air purifier with air quality monitoring system.

Mamunur Rashid [3] designed and developed an advanced Air Purifier Facial Mask as shown in fig 2.3. The components which are used to develop this system are Arduino NANO, HC-05, Resistor, capacitor, 9V battery, Ionizer, Filter, Air pump. The main aim of this fabricated model is designing and building a low cost, wirelessly controlled advanced air purifying facial mask which everyone can afford. This system is both wireless and manually controlled. As the system is battery powered and low noise making air pump is used, so the noise interference is reduced and subject safety is ensured.

The software is implemented in two sections, one is device section and other is android application section. The device section is used to drive hardware and the application layer is for the user to control the air flow rate through android apps. To programme, the microcontroller integrated development module provided by the Arduino platform will be used. An Android application and software for the laptop is developed by processing which is an open-source programming language and Arduino IDE. To develop the system there will be used Processing IDE of version 2.20. For receiving serial data from the Bluetooth module, Biserial library will be used. For developing the software used in laptop serial library of processing was used to receive the data from Arduino Nano. The component used for this system consumes very low power and it takes maximum current of 55 mA. It is capable of running about 8hrs by one full charge. It can be more cost efficient by further development in future.

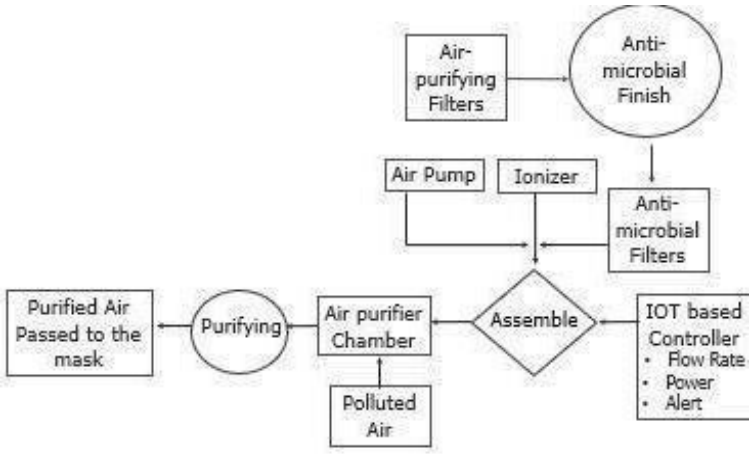

Fig 2.3 Flow chart for Advanced Air Purifier Facial mask

David Ardmar [4] developed an air cleaning equipment in buildings as shown in fig 2.4. This fabricated model resulted in an air purifier concept that is developed in the view of sustainable and fulfils user requirements. The feedback taken from users together with their own preferences, from that the air purifier is designed to blend in with home furnishings and still express the cleanliness. This project also resulted in a patent application for a new type of filter that the users can clean themselves without the need to continuously buy new filters using Activated carbon and HEPA filter. The filter also consumes less energy, and it occupies less space compared to others on the market. And there's less usage of material which results in less negative impact on environmental. Ionizer helps to purify the air in a room by electrically charging air molecules.

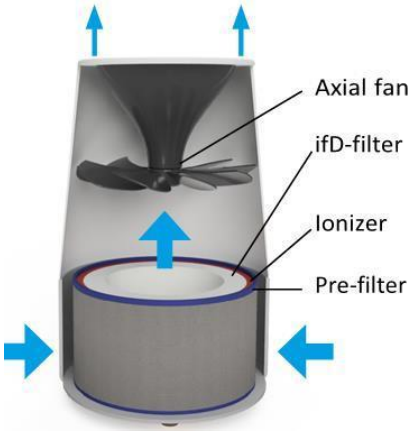

Fig 2.4 Easy handling air purifier

Yash Gupta [5] their team designed and developed an air purifier using HEPA filter as shown in fig 2.5. Design an Air Purifier which operates with 6 advanced stages of filtration using: a cold catalyst filter, a cellular-activated carbon filter, an anti-microbial filter, a HEPA filter, an ionizer, and a UV sterilizer. Cold Catalyst Filter: It catalyses and removes harmful household chemicals like formaldehyde, ammonia, benzene, TVOC, hydrogen sulphide and other gases.

Activated Carbon Filter: Absorbs and collects dust, pet hair, allergens, smoke fumes and harmful gases. 34 Antibacterial Filter: Efficiently removes bacteria, viruses and moulds in the air. HEPA Filter: Captures 99.97% of airborne contaminants like dust, bacteria, fungi, viruses, and allergens. UV Light: Destroy micro-organisms such as germs, viruses, fungi and bacteria. Ionizer: Releases anions that help remove airborne particles like floating dust, bacteria, viruses and smoke.When the power is turned on the fan present about the filters create a suction action in the empty space present below the filters. Due to this the surrounding air enters into this area and gets sucked into the filters. At first the air enters the cold catalyst filter and the air s purified from the harmful gases like formaldehyde, ammonia, ozone, benzene etc., gases.

Fig 2.5 Air purifier using HEPA filter

Anuj Tiwari [6] designed Low-Cost Homemade Air purifier as shown in fig 2.6. It consists of UV, HEPA, Air pollution, Air ionizer compartments. Air purifier is provided having a purifier housing and an air way housing mounted therein. And the working principle is the fan which helps to circulate the air present in indoor and they have used brushless DC motor in the experimentation which is advantageous because we don't need to worry about the breakdown of motos as like others, and the air will pass through the Pre-filter, Medium filter, BIO-GS filter, HEPA filter & activated carbon filter where impurities will be trapped like HEPA filter captures smoke & dust particles and activated carbon filter captures impure carbon molecules. An extended and tapered discharging copper needle is electrically coupled to a high voltage generator contained within the purifier housing and produces negative ions. The discharging needle is pointed in contour and has an apex end located adjacent the air exit opening. The discharging needle extends in the direction of the passage of high-pressure air from the purifier housing which allows the discharging needle to vibrate responsive to the high-pressure air flow and increases the number of negative ions mixed with the air passing from the purifier housing.

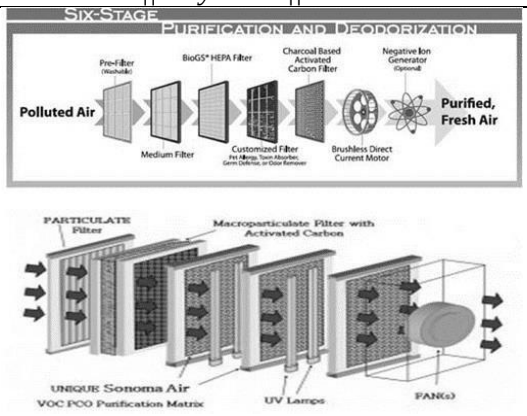

Fig 2.6 Low-cost home-made air purifier

Swiss Manufacturer Plaston [7] has developed a model Boneco P2261 as shown in figure 2.7. This air cleaner combines high efficiency, functionality and traditional European quality. System of filtering elements includes pre-filter, filter class HEPA and coal filter. Passing through coal filter air is completely purified of bacteria. Air cleaner Boneco P2261 is economical, silent and has three levels of power. It can be used both in homes or offices,

The principle of operation is following: after mechanical filters air is supplied to allergies HEPA filter. Air is cleaned from dust, pollen, pet dander, dust mites and other micro particles. Cleaned air goes to the coal filter, which reduce the gaseous substance, includingtobacco smoke and unpleasant odours. One of the functions of Boneco P2261 is air ionization.

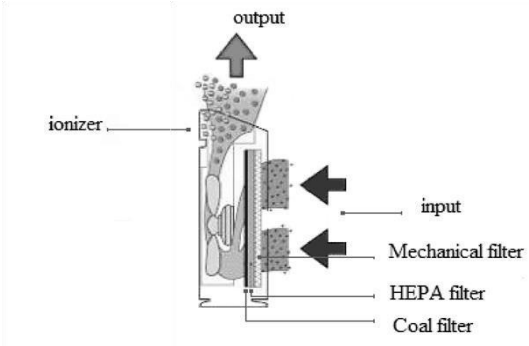

Fig 2.7 Boneco P2261 Air Cleaner

The Chinese company Ballu industrial group has developed a model Ballu AP250 as shown in fig 2.8which is efficient air cleaner with five air-filter system (HEPA filter, coal filter photocatalytic filter, ultraviolet lamps and ionizer). The air is purified and so prevented the risk of respiratory diseases. The air cleaner is often installed in bedrooms, children's rooms and offices. Air goes through 5 degrees of purification and is achieved good efficiency. As a result, micro-organisms are killed; the dust is arrested, pollens and other allergens, tobacco smoke and other odours are removed. The air cleaner has three modes of power and operates with low noise level.

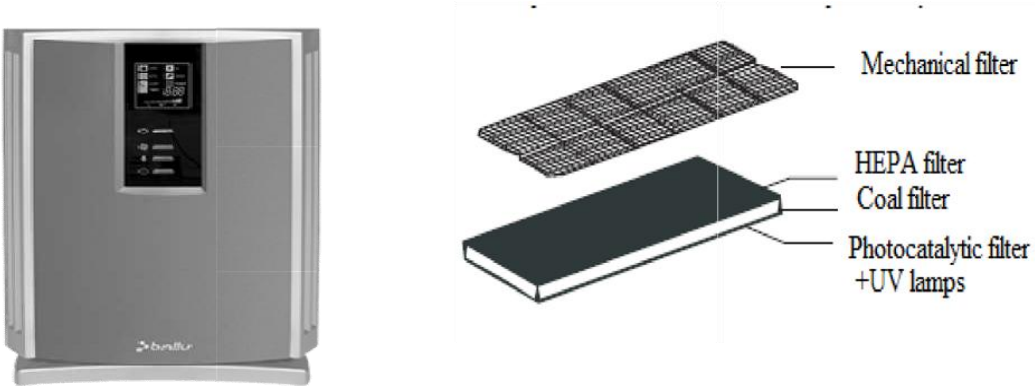

Fig 2.8 Ballu AP250 Air cleaner

Dikshant Gogia (9) designed and fabricated anIntegrated Air purifier for Vehicle/homes as shown in the figure 2.9. In this model the quantity of particles in the vicinity of 0.5µm and 2.5µm inside while utilizing moderate air purifiers in the profoundly dirtied city of Delhi. Infact that significant decreases in indoor number fixations are seen amid air purifier utilize, indoor air quality while utilizing an air purifier is oftentimes more terrible than in urban communities with direct contamination, and frequently more regrettable than levels watched even in dirtied urban areas. When air contamination levels are higher, by and large, indoor contamination levels while utilizing an air purifier are likewise higher in this model. Additionally, the proportion of indoor air quality amid air purifier use to two examination measures of air quality without an air purifier are likewise emphatically related with open air contamination levels, recommending that as encompassing air quality compounds there are unavoidable losses to upgrades in indoor air quality amid air purifier utilize.

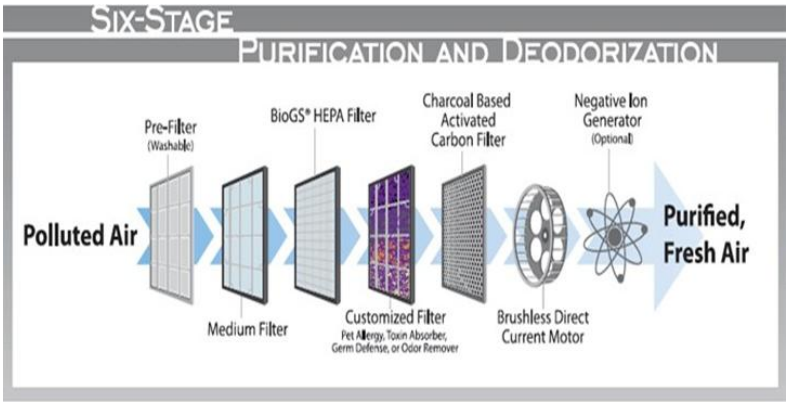

Fig 2.9 Design of Integrated Air purifier for Vehicle/homes

Manjeet Kumar [10] designed Solar Powered Air Purifier as shown in fig 2.10. This research work emphases on design and fabrication of an air purifier which is powered by solar energy and testing the effectiveness of the system to curb the air pollution. The focus is on extracting the suspended particulate matter from the air which are the major contributors in the pollution of air in many urban cities. It works on a non-conventional method and intents to achieve best possible air purification results using eco-friendly and economical method. It works on the basic principle of adhesion of the suspended particles in the air with the liquid and settles down due to being heavier than air and gets separated from the air helping us to achieve better air quality index. The fans and the pump in system are operated with the help of solar energy, produced by solar panels, which converts the solar radiations into electricity,

Air purifier consists of chamber in which air is sucked in by the fan, while the air is entering it passed through strainer. Simultaneously water is pumped from reservoir to the atomizer, which converts water into small water droplets and these droplets are suspended into the chamber along with air. These water droplets have adhesive property due to which the particulate matter and dust particles get absorbed on them. This way air is cleaned and is flown out from chamber by exhaust fan. The water with dust and particulate matter is collected in evaporation tank, where water under goes natural evaporation process, leaving behind the dust and particulate matter these are periodically cleaned and water is used again in air cleaning process.

Fig 2.10 Solar powered air purifier

Rohit. [11] Designed solar powered air purifier model as shown in below fig 2.11. When solar energy provide required load and battery is also fully charged, then charge controller provide charge directly to the high voltage Generator that is Marx generator. Marx generator works on low voltage supply to generate high voltage

pulse. When solar energy is not available then battery provides voltage to Marx Generator to generate high voltage at electrode. There are two gas sensors in the circuit at both ends of high voltage Electrodes. Initial gas sensor senses which pollutants are present in the air and shows that on LCD display.

When gas is passed through the electrode's ionization takes place and Pollutants are absorbed in the electrode. Filtered gas is again sensed by another gas sensor and again pollutants if any present are displayed on the LCD display. This purifier reduces particulate level to satisfactory position where a person does not need to worry about pollution related problems.

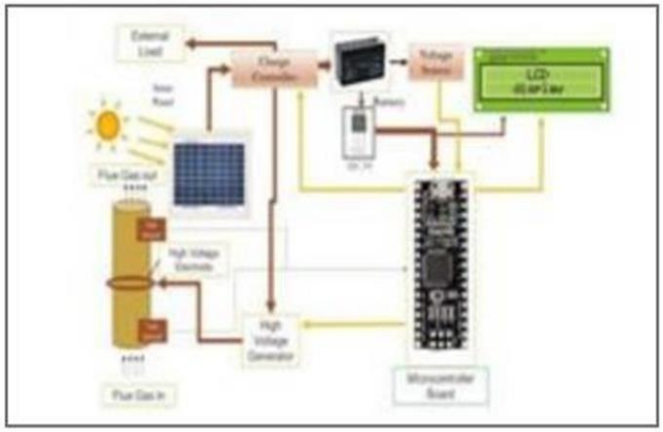

Fig 2.11 Design and fabrication of solar powered air purifier model.

Karoline [12] developed Low-cost Sensors to Quantify the Effects of Air Filtration on Indoor and Personal Exposure Relevant PM2.5 Concentrations as shown in fig 2.12. Which uses Air filter, SD card, LED indicator, PM2.5 sensor, Temp sensor, and microcontroller and Voltage Regulator?

This work demonstrates an efficient 2-step approach to calibrate low-cost monitors against a single unit that has already been calibrated as opposed to calibrating them directly against a reference monitor (viz., a TEOM), thus reducing the collocation time required for calibrating numerous monitors, as only one monitor must be collocated with a reference analyser for an extended period of time. After applying this method, the low-cost monitors displayed low inter-monitor variability. This experiment proves the feasibility of deploying low-cost monitors for indoor, outdoor, and personal exposure monitoring. The low correlations between the personal exposure and outdoor measurements suggest that these devices should monitor conditions in addition to the ambient Particulate $Matter_{2.5}$ concentration, which, in itself, cannot provide an accurate estimate of personal exposure.

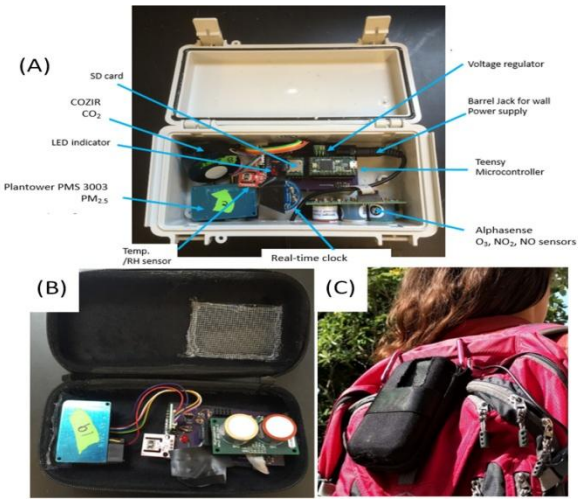

Fig 2.12. (a) All sensor package components in indoor/outdoor sampling case,
(b) Personal monitoring case with internal components, and
(c) Personal monitor hanging on a backpack.

Aditya Roy [13] carried out a review of general and modern methods of air purification". This article focused on current scenario related to air pollution problems and different air purifier filters used. A compilation of most common and significant methods of purifying air such as use of HEPA filters, electrostatic smoke precipitators, activated carbon and UV light has been presented and their use in air purifiers are manufactured by OEMs. Some of the modern methods of purifying air such as those using transparent PAN filters, photochemical materials, soy proteins and silk nanofibrils have also been studied and reviewed. It has been found that these methods provide an attractive and economical pathway of filtering out Particulate Matter 2.5 when compared to the conventional HEPA filters. A very attractive method of curbing industrial air pollution is to use electrostatic smoke precipitators, their advantage are like filtering out every possible category of air pollutants starting from particulates to odour and promise a very high efficiency of 99.97%, butvery expensive.

Angela (14) reviewed indoor air treatment technologies. This review focuses use of single treatment techniques such as mechanical and electrical filtration, adsorption, ozonation, photolysis, photo-catalytic oxidation, biological processes, and membrane separation. Since there is currently no technology that can be fully satisfy for achieving cleaner indoor air, special attention is paid to combined purification technologies or innovative alternatives that are currently under research and have not yet been commercialized (plasma-catalytic hybrid systems, hybrid ozonation systems, bio-filter-adsorption systems, etc.). And in these systems seems to be a good opportunity as they integrate synergetic advantages to achieve good indoor air quality. The authors have explained about three basic strategies to be applied to reduce indoor pollution, and improve Indoor Air Quality. The first strategy focuses on the control of the pollution source, which can be accomplished by its removal, confinement, or replacement. A second strategy involves improving the ventilation system by increasing the amount of outdoor air to dilute indoor pollutant concentrations. This alternative does not necessarily negate the presence of pollutants above a safe limit and may involve the potential risk of simply bringing in more pollutants from the outside, and what's more, it is inconsistent with energy saving policies. Finally, the third strategy involves the use of purification/treatment technologies.

Ewa [15]worked on Efficiency and Eco-Costs of Air Purifiers in Terms of improving microbiological indoor air quality in Dwellings. An increasingly popular method to improve Indoor Air Quality is to use air purifiers (APs). Indoor air is often polluted by bioaerosols (e.g., viruses, bacteria, fungi), which are a major concern for public health. This work presents research on culturable bacterial aerosol (CBA) samples collected from dwellings with or without active APs during the 2019 summer season. The CBA samples were collected using a six-stage Andersen cascade impactor (ACI). Their conceptual approach addresses the impact of indoor air pollution on human health and estimates the ecological cost of APs and air pollution prevention policies. It can be observed that air purification has a cost and an impact on the environment, the cost can be minimized by eco-design production.

Michel Ondarts (16) worked on Indoor Air Purification by Compost Packed Bio filter. This work focused on bio filter &evaluated bio filter performances for IAP treatment . The biofilter is packed with compost, a natural medium which has a large range of microorganisms, good physical properties (water retention, pH) and contains nutrients. The model effluent contains 8 compounds (aldehyde, aromatic, chlorinated, inorganic), at low concentration, chosen for their ubiquity in indoor air, their heterogeneous physical and chemical properties (solubility, vapor pressure, biodegradability) and their potential health risk due to chronic exposures. Biofilter performances were evaluated during 75 days in steady state. The efficiency close to 100 % during the first 40 days. After this time, efficiency variations were observed and the removal efficiencies decreased to 55.5, 77.8 and 13.9 %. The results showed that mature green waste compost as packing material in a biofilter has shown a good efficiency in indoor air treatment for the removal of several pollutants in a model.

Conclusion

Increased Air pollution results in higher rate of contaminants like industrial dust, smog and other particles from traffic in Air. Breathing polluted Air is risky and harmful to health. Quality of air can be improved by using Air purifiers available in the market, but these are costly. This paper reviews fabrication of air purifiers using different fibers, bio-filters, UV lamps and can be powered by solar energy resulting in low-cost air purifiers.

Reference

[1]. Rushikesh Kadam , Oshin Pojta, Kunal Jagtap, "Fabrication and Design of Solar Powered Air Purifier for improving Air Quality Index", Journal of Emerging Technologies and Innovative Research , Volume 8, Issue 4, 2021, pp 525-534

[2]. Perumal, Saravanakumar, Vignesh & Padmanab bhaniyappan, "Solar powered Air-Purifier with Quality Monitor system from Dept. of Electrical & Electronics engineering, SRM Valliammai Engineering college, Chennai, Tamil naadu, India.
[3]. Md Mamunur Rashid, Sadman Sakib Tushan, Sharif Ahmed, Shariful Islam Tushar, "Design and Development of Advanced Air Purifier Facial Mask". Published in Proceedings of the International Conference on Industrial Engineering and Operations Management Bangkok, Thailand, March 5-7, 2019
[4]. Md Mamunur Rashid, Sadman Sakib Tushan, Sharif Ahmed, Shariful Islam Tushar, "Design and Development of Advanced Air Purifier Facial Mask". Published in Proceedings of the International Conference on Industrial Engineering and Operations Management Bangkok, Thailand, March 5-7, 2019
[5]. David Ardmar, Johan Bodin, "Design of an air purifier - with focus on function and aesthetic design". Published and distributed by Luleå University of Technology SE-971 87 Luleå, Sweden.
[6]. Anuj Tiwari 1 and Amit Tiwari 2, A Low Cost Homemade Air purifier, AKGEC International Journal Of Technology, Vol. 10, No. 2, pp 16-21
[7]. BONECO P2261, article from https://www.manualslib.com,
[8]. BALLU AP250. Published in http://www.ballu.ru/manual/Manual_AP250indd.pdf. Referred 14.01.2011
[9]. Dikshant Gogia, Chirag Kaushik & Gaurav Hasija Final, from Dept. of EECE The Northcap University, Gurugram, Haryana, India. Published in International Journal of Computer Science Engineering (IJCSE) ISSN: 2319-7323 Vol. 7 No.03 May-Jun 2018.
[10]. Manjeet Kumar, Satinder Jeet Singh, Prabhat Kumar Shukla, Raj Varun Singha Manash Dey, Ashutosh Singh, "bionaire air purifier" International Research Journal of Engineering and Technology, Volume: 05 Issue: 04, 2018, pp 3528-3534
[11]. Rohit B Madane, Aniket & Suraj, "Air purification by using Solar Power resolving Air pollution problem" from Dept. of Electrical engineering, Singhad institute of technology, Lonavala, Pune, India. Published in Open Acess International Journal of Science & Engineering.
[12]. Karoline K. Barkjohn, Michael H. Bergin, Christina Norris, James J. Schauer, Yinping Zhang, Marilyn Black, Min Hu, Junfeng Zhang, "Using Low-cost Sensors to Quantify the Effects of Air Filtration on Indoor and Personal Exposure Relevant PM2.5 Concentrations in Beijing, China" Aerosol and Air Quality Research, 20: 297–313, 2020
[13]. Aditya Roy, Chetan Mishra, Sarthak Jain & Naveen Solanki "A REVIEW OF GENERAL AND MODERN METHODS OF AIR PURIFICATION" by. Published in Journal of Thermal Engineering, Vol. 5, No. 2, Special Issue 9, pp. 22-28, February, 2019.
[14]. Angela Luengas, Astrid Barona & Cecile Hort "A review of indoor air treatment technologies". Published in Reviews in Environmental Science and Bio/Technology ISSN 1569-1705 DOI 10.1007/s11157-015-9363-9.
[15]. Ewa Br agoszewska, Magdalena Bogacka and Krzyszt of Piko "Efficiency and Eco-Costs of Air Purifiers in Terms of Improving Microbiological Indoor Air Quality in Dwellings" Published in Atmosphere 2019, 10, 742 ; Published: 26 November 2019
[16]. Michel Ondarts "Indoor Air Purification by Compost Packed Biofilter". Published in International Journal of Chemical Reactor Engineering Volume 8 2010 Article A54.