

## SOLAR OUTDOOR AIR PURIFIER WITH AIR QUALITY MONITOR

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## ABSTRACT

Pollution is increasing very effectively in the world. It must be reduced the present pollution levels by the deadline even though the long-term solution to the pollution problem is to identify and reduce pollution sources. The use of air purifiers is the most effective method of reducing pollution. Regular interior air purifiers, however, are little, low-power gadgets that lack the necessary filtering capacity for outdoor environments. Additionally, there is a problem with outdoor machines' power supplies. Therefore, it has created a solar outdoor air purifier that is energy independent and built for outside filtration. It is powered by solar panels. A powerful suction fan at the bottom of our solar air purifier draws air up through a layer of pre-filters, High-Efficiency Particulate Absorbing (HEPA) filters, carbon filters, and Ultraviolet (UV) lights to remove gases and (Particulate Matter) PM 10 and PM 2.5 pollutants. Prefilter, HEPA layer, Active Carbon Filter, and UV light make up the first of the purifier's four purification layers. The combination of these four filters results in the best filtration, sucking in a lot of air and clearing it of dust particles utilizing centrifugal air force.

Keywords: ESP32 Micro-Controller, Bluetooth, Sensors, DC Motors.

## INTRODUCTION

The planet is in a difficult predicament as a result of pollution, in whatever form. Metropolitan cities have significant levels of pollution. People spend a large part of their lives in areas that are polluted by hazardous substances. Sources of Pollution, building, construction, combustion of fuels, by-products of vehicles, etc. Pollutants are in the form of methane ( $\text{CH}_4$ ), carbon dioxide ( $\text{CO}_2$ ), carbon monoxide ( $\text{CO}$ ), nitrogen dioxide ( $\text{NO}_2$ ), Sulphur dioxide ( $\text{SO}_2$ ), etc. These particles create health problems like respiratory illness, decreased lung functioning, etc. The contaminated particles in the air should be purified before inhaling the air. So, it has to make a solar outdoor air purifier with an air quality monitor,

which runs on solar energy with the use of filters (Sundarrajan et al., 2014).

Today's air pollution poses a severe threat to the ecosystem, and it is not just a fact but a painful reality that is causing troubles for people's health. The air quality index has certainly reached a level in several regions of the world that necessitates an immediate solution. Hence, the purpose of this paper is to tackle this problem at a large scale by providing air purifier for "outdoors". Since most of the time, people travel outdoors and stay away from their homes for a long time.

Many things in the world have undergone significant alteration since the advent of industrial civilization. The majority of these changes have been for the better, although few had negative effects only. The issue of "air pollution" is one of them. It is a serious issue in many regions of the world. Gas chambers have been declared in some of the world's most polluted cities, including New Delhi (India), Zabol (Iran), Bamenda (Cameroon), and



This paper has objectives related to SDGS



many others. According to the World Health Organization (WHO), the air in such cities contains dangerously high levels of tiny, microscopic pollutants. Because these pollutants are small and quickly incorporated into the bloodstream through the lungs, they are the only cause of 7 million preventable deaths each year. As a result, this issue needs to be prioritized and addressed on a global scale. Numerous indoor air purifiers are produced today that especially target the air surrounding people in order to solve this issue. However, adopting indoor purifiers won't address the problem of destroying ecosystem-wide air quality. Fixing the minor issues that don't even help to solve the issue as a whole won't solve this problem, only addressing the root cause will. This study develops an outdoor air purifier with this in mind. In order for this purifier to work, fresh, filtered air must be provided in an outside environment (Mahesh, 2019).

## 1. Related Work

The previously prepared projects have made use of batteries as a source of power supply, but solar energy has been used which makes the air purifier cost efficient. Usage of filters like pre-filter, a fine filter, and test filter cannot effectively trap pathogens and microorganisms. To prevail this, active carbon filter and negative ion filter, used ultraviolet (UV) filter with High-Efficiency Particulate Absorbing (HEPA) filter. In a typical system, air is merely filtered in one direction by simply drawing it from a hazardous area and returning it there after another filtering (Perumal et al., 2021).

## 2. Objectives

Although there are many different kinds of air purifiers on the market, none of them are effective enough to do their jobs. Government organisations have a very small budget for supplemental expenses like air purifiers. Therefore, it is wise to create an air purifier that is both affordable and effective. Hence solar-powered air purifier has been developed that uses solar energy, however there is also a problem with the power source for indoor machines. In order to remove pollutants and gases from the air, our solar air purifier uses a centrifugal suction fan to draw air from the bottom of the device and pass it

through a layer of filters. While in this system, a two-way channel was included to facilitate the quick and simple elimination of undesirable particles. A solar panel generates electricity, which is subsequently stored in a battery. The electric fans of the filtration unit are then operated using this electricity. The unit uses a variety of filters to purify the air entering the room.

## 3. Methodology

Arduino Uno is used for controlling the entire system by taking the input from sensors and switching ON the Fans when required through the relay. The solar panel is used for harvesting power from solar energy and the obtained power is used as a power supply for working of the entire system. A 12V battery is used for storing the harvested power from the solar panel and this battery required power is drawn for the functioning of the system. A relay is used in the system as it is a programmable electrical switch, which can be controlled by microcontrollers and Arduino. It is used to switch ON/OFF the devices according to the program developed, which uses high voltage and/or high current. Relay acts as a bridge between Arduino and high voltage devices.

A power supply is used in the working of the system as it takes the Alternating Current (AC) and converts it to unregulated Direct Current (DC), and it also reduces the voltage using an input power transformer, typically stepping it down to the voltage required by the load for running the system. When a device needs power but lacks internal components to obtain the necessary voltage and power from mains power, an external power supply called an AC/DC adapter (AC/DC converter) is utilized. The internal circuitry of an external power supply will be as same as the design that will be present in a built-in power supply. Here air quality is monitored by using MQ series sensors. The sensors used are MQ135, MQ2, and MQ9. Two MQ135, two MQ9, and two MQ2 sensors are used. The air quality of the environmental air is measured using MQ sensors at front of the model. Here it has been placed 1-MQ 135, 1-MQ-9, 1-MQ-2 sensors at the front end for measuring the air quality of the air. It has also used 1-MQ 135, 1-MQ-9, 1-MQ-2 at the backend for measuring the air quality of the purified air. Thus comparing the values got

from the MQ series sensors which are converted from analog voltages to digital number values by the process of Analog to Digital Conversion (Powar, 2022).

An analog-to-digital converter is an electronic device that converts continuous time-varying analog signals into discrete-time digital signals. Analog to Digital Converters (ADC) converts the physical quantities of a real-world phenomenon into a digital value, which is used in control systems, data computing, information processing, and data transmission. The digital numbers used here are binary '0' and '1'. The '0' indicates the 'off' state and '1' represents the 'on' state. The ADC process is done in two steps sampling and holding and followed by Quantizing and Encoding.

#### 4. Design and Implementation

Figure 1 shows the block diagram of the proposed system. The first air quality of the environmental air is checked using 3-MQ series gas sensors. Namely, MQ135, and MQ2, MQ9 where the MQ135 sensor is used in the detection of Ammonia, Sulphur, benzene, and other harmful gases and smoke from which we get the air quality of the air and MQ2 works on 5V dc, it mainly detects Liquid petroleum gas, smoke, carbon monoxide, and methane present in the air. And MQ2 is used in the detection of Liquid petroleum gas, Methane, and carbon monoxide. MQ series gas sensors have analog and digital output pins.

When the level of the gases in the air increases beyond the threshold value the digital pin goes high. This threshold value can be varied using the onboard potentiometer. The analog output pin outputs an analog voltage which is used to approximate the level of these gases present in the atmospheric air. As gas detection relies on a change in the sensing material's resistance when the gas comes

into contact, they are also known as Chemiresistors. For measuring different types of Gases here we are using three types of Gas Sensors. MQ series sensors are to be pre-heated for 30sec to minutes to get accurate readings. Mainly here it gets the digital output values ranging from 0-1023 as the analog voltage varies according to the gas concentration present in the air from MQ-series sensors. As it is using 6 MQ-series sensors, the sensitivity of the sensors varies from one another and it is difficult to study the variations of these gas sensors. So firstly, the outputs from all sensors were considered and setting the values to the normal air quality index of the room without pollution for the Approximate range 45-50. By doing this, it becomes easier to study the variation of the sensor's outputs as the gas concentration varies.

The output from these sensors is taken to the Arduino. Here it gets the digital output values from these sensors which can be used to study the variation of gases. Here to be considered the digital output values from the sensors as the Air Quality Index, which is used to measure the quality of atmospheric air. The output from three MQ series sensors namely MQ135, MQ2, and MQ9 which are present on the front side of the model is taken for checking the air quality of atmospheric air. According to the national Government pollution board if the air quality index of air ranges from 0-50 the air is considered good. The air quality is deemed moderate if the air quality index falls between 51 and 100. For sensitive groups, the air is deemed hazardous and maybe dangerous if the air quality index falls between 101 and 150. If the air quality index is between 15 and 200, it is considered unhealthy and potentially harmful to breathe. If the air quality index falls between 201 - 300, it is thought to be extremely hazardous and harmful to breathe. When the air quality index is between 301 and 500, it is deemed hazardous and can make you sick if you breathe. The output from these sensors is taken to the Arduino. Here we get the digital output values from these sensors which can be used to study the variation of gases. Here we are considering the digital output values from the sensors as the Air Quality Index, which is used to measure the quality of atmospheric air. The output from three MQ series

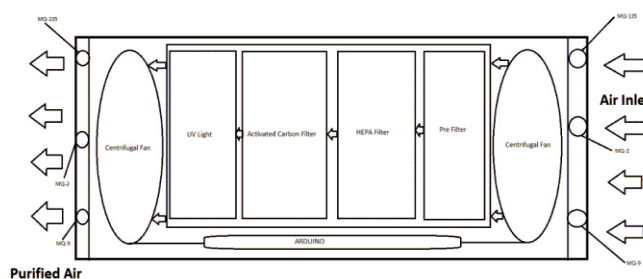


Figure 1. Block Diagram of the System

sensors namely MQ135, MQ2, and MQ9 which are present on the front side of the model is taken for checking the air quality of atmospheric air. According to the national Govt pollution board if the air quality index of air ranges from 0-50 the air is considered as good. If the air quality index of the air ranges from 51-100 then the air quality is considered moderate. If the air quality index of the air ranges from 101-150 the air is considered unhealthy for sensitive groups and may be dangerous for sensitive groups. If the air quality index of the air ranges from 151-200 the air is said to be unhealthy and dangerous for people if inhaled. If the air quality index of the air ranges from 201-300 the air is considered to be as very unhealthy and very dangerous if inhaled. If the air quality index of the air ranges from 301-500 the air is considered hazardous and causes ill if inhaled.

So as the air is said to be unhealthy if the air quality index goes beyond 100. Thus used the threshold value as 100. If the digital output of the sensor goes above 100, as the air is considered polluted and unhealthy for inhaling it should be purified. So, the centrifugal fan/Blower has been switched ON at the front end of the model for sucking the air in for purifying the polluted air.

Now the air gets passed through Pre-Filter where large particles are filtered/removed before it reaches the main filter including sand, stones, dust, insects, pollen, and various fibers are removed. And then the air purified from large particles by pre-filter gets passed through a high-efficiency particulate filter where filters work by trapping particles in a mesh of very fine fibers. These fibers are so small that they can trap particles as small as 0.3 microns in diameter where dust, pollen, and other airborne contaminants are removed from the air. HEPA filters can remove up to 99.97% of pollutants from the polluted air. Now the air becomes free from large particles and many pollutants which are now passed through active carbon filter where odours, gases and volatile organic compounds present in the air are removed. Now the air gets free from large particles, pollutants, odours, gases volatile organic compounds which are passed through UV light where pathogens, bacteria, and viruses are killed. Now the air is let out into the atmosphere by the blower

present at the back end of the model. Here by using MQ series sensors the air quality of the purified air is checked by using digital values from analog voltages and these values are fed to Arduino. The quality of the air is sensed all the time using the MQ sensors. If the air quality index value is greater than 100 then the centrifugal fan is switched ON for sucking the air in to purify the polluted air else if the air quality index is less than 100 the air quality is considered as good and no need to purify and hence the centrifugal fan is not switched ON (Aditya, 2018).

Coming to the pin connections has connected MQ135 present at the front which is used for checking the quality of atmospheric air to be purified or not i.e., MQ135-1 to A0 of Arduino MQ135 present at back used for checking the quality of purified air i.e., MQ135-2 to A1 pin. MQ2 is present at front of the model used for checking the quality of atmospheric air to be purified or not i.e., MQ2-1 is connected to A2 of Arduino. MQ2 present at back used for checking the quality of purified air i.e., MQ2-2 to A3 pin of Arduino. MQ9 is present in front of the model used for checking the quality of atmospheric air to be purified or not i.e., MQ9-1 is connected to A4 of Arduino. MQ9 present at back used for checking the quality of purified air i.e., MQ9-2 to A5 pin of Arduino. The process involved in using MQ series sensors is the analog voltage got from these sensors is converted to voltage values ranging from 0-1023 according to our Arduino as our Arduino operates on a 10-bit analog to digital converter. The flowchart in Figure 2 shows the overall process is done in a simple form and the flow chart of the system.

Air Quality Index (AQI) is measured if it is greater than the threshold value (100) and then the centrifugal fan is switched ON to suck the polluted air in. If the AQI is less than 100 then the centrifugal fan is not switched ON.

## 5. Results and Discussion

The first air quality of the environmental air is checked using 3-MQ series gas sensors. Namely MQ135, MQ2, and MQ9. When the Air-Quality index of the environmental air is greater than 100 then the centrifugal fan sucks the air in and the air is passed through filters. Through this, it gets purified air. An implemented model of solar outdoor air



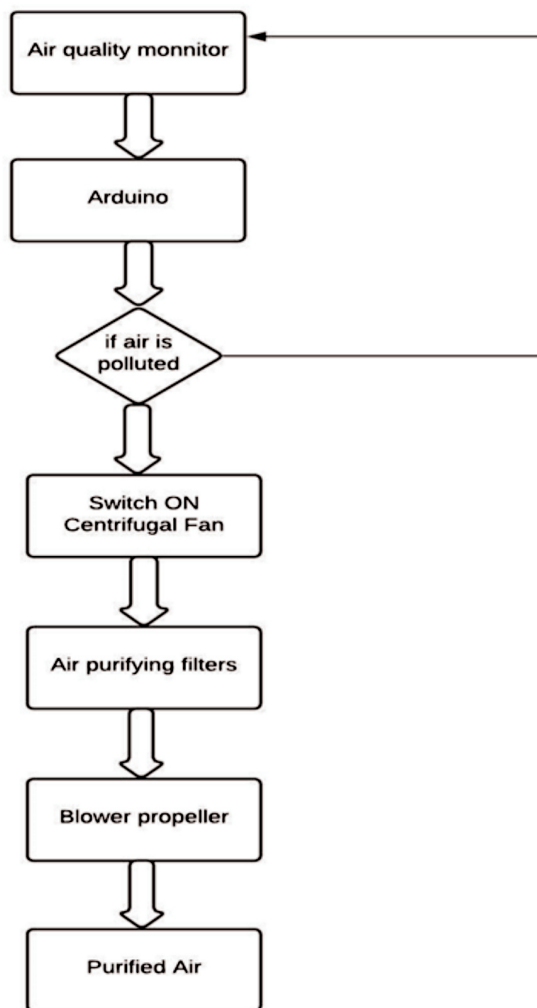


Figure 2. Flowchart of Design

purifier with air quality monitor as shown in Figure 3 and final outlook of the project is shown in Figure 4. The summary of the output is depicted in Table 1.

## Conclusion

This work now assess how effective the model is for various market-available device types. Additionally, it is relatively affordable and does not require a quick component replacement. It brings the particle level down to a safe level where a person can live without worrying about pollution-related issues. All living things on this planet have the right to pure and clean air, and an initiative is a tiny effort on this part to ensure that they all have that right. The design, execution, and testing of environmental air parameters benefited greatly from this project. The design process also contributed to a greater



Figure 3. The Proposed Model



Figure 4. The Final Outlook of the Project

Smoke	AQI Before	AQI After	Efficiency %
Burning of incense stick	109	71	38
Burning of dry grass	115	80	35
Burning of wood	126	83	43

Table 1. The Output

understanding of the importance of daily air quality. Generally speaking, the design achieves its goal of creating a user-friendly, affordable, portable, versatile environmental monitoring gadget. In general, this portable equipment can test air parameters in real-time and record the findings for upcoming long-term air quality investigations. Additionally, it is more economical for users because to its solar power supply architecture and low consumption components. The device's architecture also allows for future expansion of its functionality. The main environmental issue, "Air pollution," has persisted for

a while and is now unquestionably causing climatic change, which is seriously affecting human health. Instead of a long-term solution that won't work for a few years, this circumstance calls for a quick exit. This model might serve as a remedy in this situation. The proposed work's goal is to reduce pollution in a specific outdoor area by measuring the air quality index of an area with higher air quality index using MQ series sensors, and then purifying the air with filters. Inhaling safe air wherever is made possible by the solar outdoor air purifier using air quality monitoring system in this manner. Gas sensors are part of the monitoring process. When the results of each of these calculations are displayed on the screen, the air is purified if the air quality index is higher than the threshold value. The proposed study intends to create a mobile autonomous air purifier that can assist in purifying outdoor air in this way.

## Future Work

The project can be improved by using much more high-power centrifugal fans for covering a much larger area. The project can be upgraded using more solar panels and can supply excess power to external resources. To control and watch the functioning of the model in Androids using Global System for Mobile (GSM).

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