



# Design & Implementation Of Portable Air Purifier With Air Quality Monitoring System

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**Abstract:** According to current scenario outdoor air quality are getting worse due to some industrial activities or vehicles, etc. that also affect indoor air quality such as home, hospitals and some Over-Polluted Areas it affects human health, specially new born child and those who have already respiratory problems, so we made a portable air purifier that Measure air quality in real-time. It included a Pre-filter, Activated Carbon, and HEPA filter to trap dust, gases, and VOCs. We also added sensors for temperature, humidity, CO<sub>2</sub>, PM<sub>2.5</sub>, and VOCs to keep everything in check. With the ESP-8266 module, you can Monitor or control it through a mobile app or web interface. This system is Portable, saves energy, and is super easy to use, covering 100-300 sq. ft. perfect for Indoor spaces such as homes, offices, or small shops.

**Index Terms** – Portable air Purifier, Air Quality Monitoring, ESP-8266, IOT (Internet of Things), PM<sub>2.5</sub>, VOCs, HEPA Filter, Indoor air Pollution, Energy Efficiency.

## I. INTRODUCTION

Air pollution is becoming a serious headache, especially in cities where indoor air quality affected by outdoor air quality. Harmful stuff like PM<sub>2.5</sub>, CO<sub>2</sub>, and VOCs messes with our breathing and health [8]. According to market survey both the air purifiers eat up a lot of power and don't tell you what's happening with the air. So, we came up with a small, energy-saving purifier that cleans the air and gives you real-time updates on its quality. Studies have investigated things like HEPA filters, activated carbon, and UV light for cleaning air, and lately, smart sensors are making systems sharper. But most options out there are either too pricey or too bulky. Our design mixes proven technique with live monitoring to make something affordable and practical for everyday use.

Several Studies have Explored different air purification techniques, including HEPA filtration, activated carbon filtration, etc but we doesn't find any efficient air purifier that can be affordable, energy efficient and portable easy to carry any indoor spaces, so we decide to make a perfect design of air purifier that must be affordable, minimum energy consumption and use of better filtration techniques.

## II. PROBLEM STATEMENT

Air Pollution is a big threat these days especially New-born child's and those who have respiratory issues, there are some harmful pollutants such as PM<sub>2.5</sub>, VOCs, etc. are slowly messing our health, causing respiratory issue or breathing problems. The challenge is to made a Portable design, Energy efficient, low-cost air purifier with real time monitoring system and providing remote monitoring capabilities via an IoT platform. There are some issues with traditional air purifier are followed:

**Energy Consumption:** There are some traditional air purifiers that use a high-power component that lead to high power consumption.

**Size and Cost Issues:** Most of the purifier are bulkier it is too big for small spaces such as home, office, hospital ward, etc. and heavy to carry anywhere in indoor spaces, also cost of the purifier is very high.

**Lack of Awareness:** People don't even know how badly the air affects due to outdoor air pollution, People often lack access to affordable tools to monitor pollutants such as PM2.5, PM10, ultra fine dust without having Affordable air purifier with real-time monitoring system.

### III. MEASURING UNIT

**1.PM2.5 Sensor:** In our Portable air purifier we use this PM2.5 sensor, basically this sensor measures the concentration of fine particulate matter in the air that detects pollutants like dust, smoke and other tiny particles that affect breathing quality and also, this sensor is used in our system for monitoring purpose.

**2.MQ135 Gas sensor:** The MQ135 gas sensor in our system help us to detect harmful gases such as Ammonia (NH<sub>3</sub>), Nitrogen Oxides (NO<sub>x</sub>), Benzene, Smoke, etc. for monitoring to know which harmful gases present in indoor space.

**3. CO2 Sensor:** This sensor basically tracks carbon dioxide level in the indoor space, that help us for our purifier system to ensures proper ventilation and alerts if CO<sub>2</sub> levels became unhealthy.

**4.DHT22 Sensor:** In the context of air purification the parameters of Temperature and Humidity is also plays a crucial role so, basically this helps us in our system to measure temperature and Humidity levels, to maintain a comfortable environment by adjusting fan speed or purifier mode.

**5.ESP-8266 Wi-Fi Module:** The use of this module in our system to enables remote monitoring and it controls through Bluetooth or Wi-Fi from a specific app or web portal.

All these sensors in our system connected to the Arduino board to gather real-time data. The overall data is processed and used to control the fan speed and Purification mode. The Arduino sends real-time sensor data to the ESP-8266, Which then transfer it to Mobile app or web portal that we use for remote monitoring.

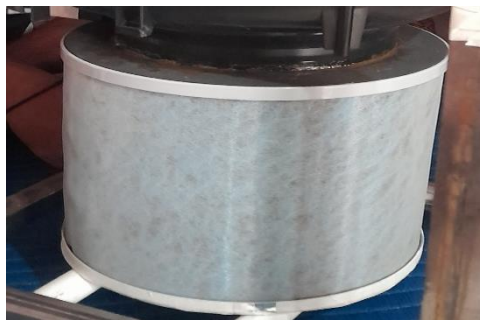
### IV. SUCTION UNIT

- **Suction Fan (24V BLDC):** The heart of our purifier is suction unit, we use a 24V BLDC Fan, it pulls in dirty air at a solid 66-67 CFM (Cubic feet per Minute), which is perfect for a 100-300 sq. ft. area. Also, by using MOSFET adjusts the fan speed based on real-time air quality data from the sensors, optimizing energy use.

### V. FILTERING UNIT

In our Purifier we use three-Step Filtering setup, all packed into a Round Shaped design, that can capture every type of Particulate matter or smoke and also harmful gases for better filtration and additionally we use of UV (Ultra violet) tube for killing germs and viruses. Three step-filtering goes through three different filters that each filter has their own configuration are to be followed:

- Nylon Pre-Filter
- Activated Carbon Filter



- HEPA Filter

**Figure 1. Round-Shaped filters**

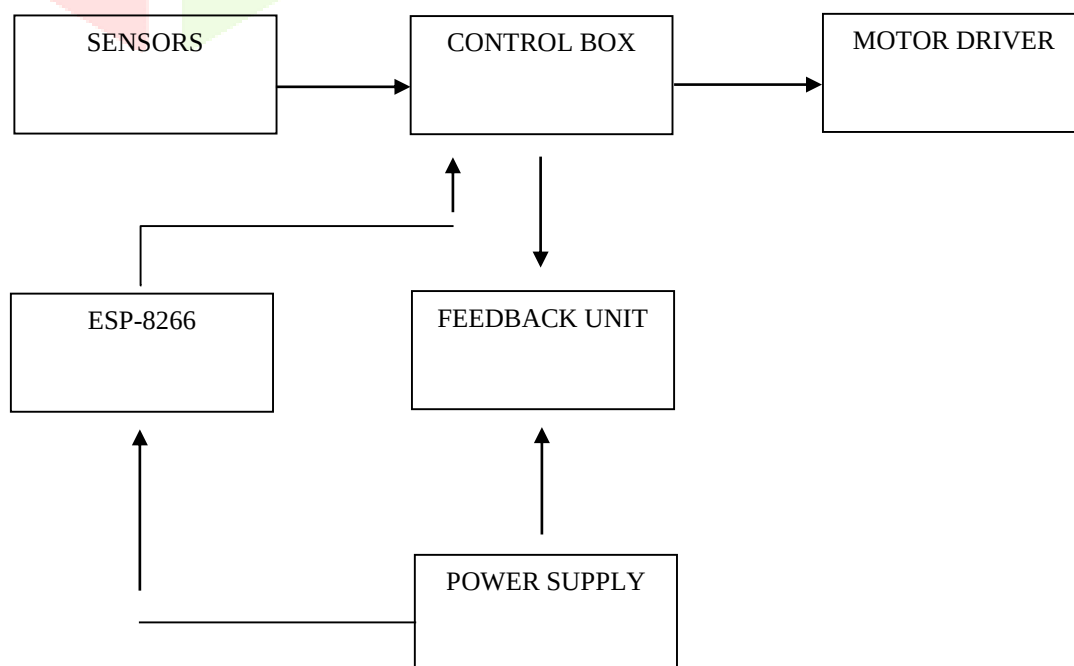
**1. Nylon Pre-Filter:** The first filter in line is the Nylon Pre-filter, shaped round to cover the whole outer layer. Its like a tough shield that grabs the big particles such as hair, dust or any chunky bits floating in the air. We made in this way so it wraps around the system perfectly, stopping the larger mess from clogging the other filters inside and keeping things running without hitch.

**2. Activated Carbon Filter:** The next filter we use in the system is activated carbon filter, it also the round-shaped to fit snug in the middle layer. Basically, it filters the VOCs, Smoke and weird smells like cooking fumes or chemical whiffs. The cylindrical design helps it catch easily and also leave the fresh air without any smelling.

**3. HEPA Filter:** The HEPA (High Efficiency Particulate Air) filter that we use in round-shape to match the setup. Basically, it built to trap 99.97 % of particles as small as 0.3 microns such as PM2.5, Bacteria, dust, pollen, etc. The Cylindrical shape makes sure it grabs all the tiny junk from every direction as air flows through, keeping the air super clean for indoor spaces like homes or offices.

**4. UV (Ultra Violet) Tube:** Additionally, the UV tube is used for killing germs, viruses and bacteria to ensure better air filtration. Basically, it deactivates the DNA of bacteria and viruses, rendering them harmless.

## VI. SYSTEM BLOCK DIAGRAM



**Figure 2. Block Diagram of Portable Air Purifier**

This Block Diagram Shows how our Purifier System is put together. The sensors like PM2.5, MQ135, CO2 and DHT22 Keep monitoring air quality and send all the data to the Arduino Uno. The Arduino-Uno decides what to do and talks to the motor driver to spin the BLDC fan at the right speed for cleaning the air. The ESP-8266 hooks everything up to the smart life app or web interface through Wi-Fi or Bluetooth, so we can monitor air quality and control the purifier's parameters. There's also a feedback unit adjust s fan speed and purification mode based on sensor data, ensuring optimal performance under varying air quality condition. Also, the 5V adapter is there for giving power supply to the Arduino and obviously the voltage controller is there for BLDC 24V fan.

## VII. COVERAGE AREA AND PERFORMANCE

| Factors                       | Description                                                             | Estimated Range                                                                                     |
|-------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| <b>Suction Unit</b>           | BLDC Fan 24V, 66.67 CMF (Cubic Feet Per Minute)                         | 50 to 80 CMF (Adjustable Via PWM)                                                                   |
| <b>Filter Efficiency</b>      | Filter (Nylon Pre-Filter, Activated Carbon Filter, HEPA Filter)         | Filter replacement after 1 year ensures consistent performance, as per manufacturer recommendation. |
| <b>UV (Ultra Violet) Tube</b> | Killing Germs, viruses and bacteria                                     | Tube Life 8000Hrs.                                                                                  |
| <b>Air Flow Rate (CARD)</b>   | Clean Air Delivery Rate (Cubit feet per Minute or Cubic meter per hour) | 50 to 120 CMF (Cubic Feet per Minute)                                                               |
| <b>Estimated Range</b>        | Area Covered by Purifier                                                | 100-300 sq. ft.                                                                                     |

**Table 1. Performance Metrics of Portable air Purifier**

The above table shows some metrics of air purifier with some key numbers we wanted to see how our purifier works by considering the above factors that shown in the table.

## VIII. METHODOLOGY

To Build this purifier, we had to break things down step by step to make sure it actually works for a 100-300 sq. ft. indoor space. Here is a step-by-step approach for study all the aspects of purifier to make a portable and energy efficient design of system.

**1. Study of Contents of air Pollutants:** We started by looking into what's polluting indoor air, things like PM2.5, CO2, VOCs, and humidity. Reports from the world health Organization (WHO) Show PM2.5 and VOCs are big culprits for breathing problem, while high CO2 makes rooms stuffy [8]. we could pick the right sensors and filters.

**2. Study of types of Air Filter:** Next, we checked out different air filters such as Nylon pre-filter, Activated Carbon Filter, HEPA (High efficiency particulate Air) filter and even basic mesh ones. We looked at studies

and manufacturer datasheets, like how Activated carbon traps gasses and HEPA catches tiny particles, to see what each one can do [2]. This gave us a clear idea of what filters would work best for our setup.

**3. Selection of Most Efficient Filters:** Based on our study, we picked a best filter for better purification, a Nylon pre-filter for big particles, an activated carbon filter for gases and smells and a HEPA filter that grabs 99.97 % of 0.3 Micron particles like PM2.5. These choices were backed by filter efficiency data from standard air purifier research [2].

**4. Selection of Fan for Suction Unit:** For Suction, we chose a 24V BLDC fan with PWM control for speed adjustment that provide 50-150CMF (cubic feet Per Minute) also depends on its size and design. BLDC fans are efficient, high air flow have a longer lifespan and produce less noise. We picked it after looking performance specs from manufacturer datasheets, balancing power and efficiency to clean the air fast without consuming up too much energy [3].

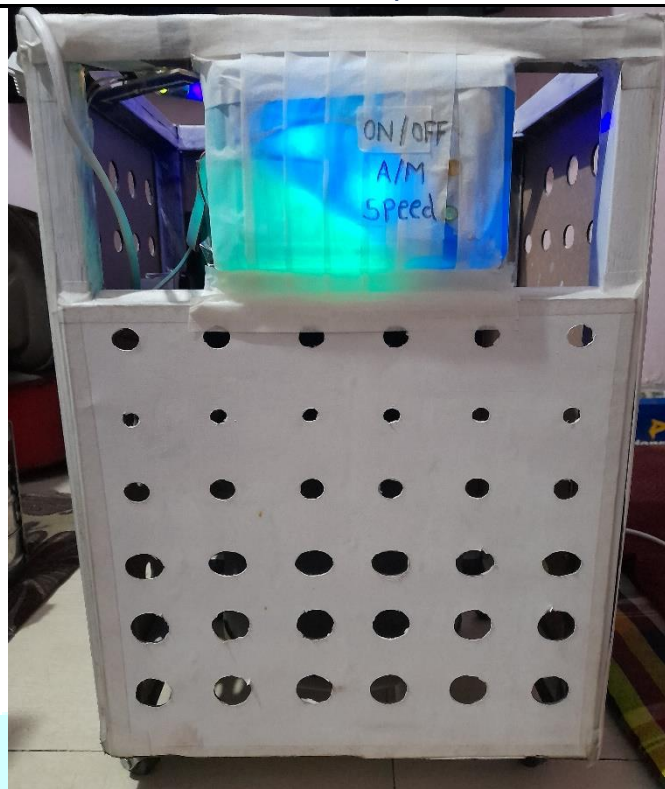
**5. Suitable app for Remote Monitoring:** To make the purifier smart, we needed an app for remote monitoring, so we went with the Smart Life app. It's a popular choice for IoT devices and works great with the ESP-8266 Module we used. The app shows the air quality and controlling Some parameters of purifier such as on/off, Auto/manual, or speed control. We picked it after looking into IoT app options, and smart life stood out for its easy setup and compatibility with ESP-8266, as noted in IoT device integration guide [13].

**6. System Design Planning:** Then we planned the whole system a Round-shaped (Cylindrical) setup for efficient filtration and also used round shaped filters. We mapped out where the sensors, Arduino and ESP-8266 would install, making sure the air flows smooth and everything connects for real-time, based on basic system design principle [11]. The design ensures efficiency airflow and minimal energy loss, as validated by aerodynamic studies.

## IX. RESULTS

The Portable air purifier, we wanted to check if our portable air purifier with an air quality monitoring system really does the job, so we put it to the test in a small 200 sq.ft. room. We built the basic setup ourselves – a simple box with air intake holes, packed with a BLDC fan, filters, sensors, and an Arduino to control everything.

To make it smart, we hooked it up to the Smart Life app using an ESP-8266 module, letting us monitor air quality live and control the purifier from our phone. For the test, we cranked things up by filling the room with smoke to spike the pollution levels, then let the purifier work its magic. We also tested it under normal conditions to see how it handles everyday air quality issues. The Smart Life app gave us real-time updates on PM2.5, CO2, and other pollutants, while the purifier's three-step filtration and UV sterilization tackled everything from dust to bacteria. The whole point was to see if it could tackle pollution in a small area, keep the air safe to breathe, and do it all efficiently without eating up too much energy. The images below show the setup, the app readings before and after, and how fast it cleaned the air, proving it's a solid solution for indoor spaces like homes, offices, or small shops.



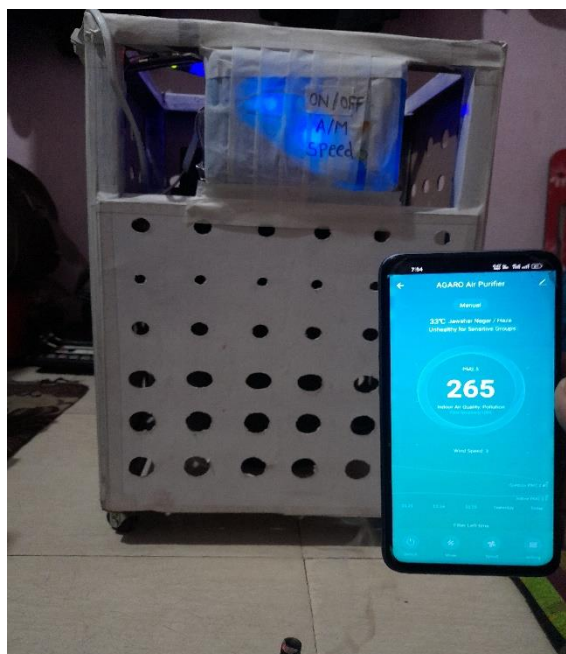
**Figure 3. Purifier Module**

The fig -3 shows the core of our purifier – the basic module we built from scratch. It's a simple box with holes punched all around for air intake, making sure the BLDC fan can pull in air from every direction. Inside, you can see the wiring, sensors, and the Arduino setup, all tucked in with the ESP-8266 for Wi-Fi control. There's a label for ON/OFF, Auto/Manual. Speed' to manually tweak the fan if needed, and a blue glow from the UV light we added for extra sterilization. It's a rough prototype, held together with tape, but it's sturdy enough to get the air moving through the filters and clean up a 100-300 sq.ft. spaces.



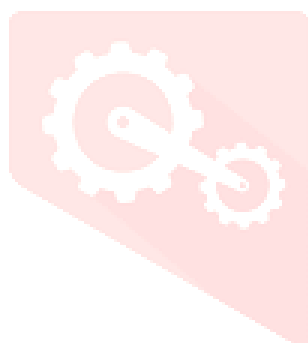
**Figure 4. Top View of Purifier Module**

The fig -4 shows the Top View of Purifier module, where you can clearly see the UV (Ultra Violet) Tube and BLDC (24V) Fan. The UV tube placed across the center to sterilize the air passes through, Killing off bacteria and viruses for extra layer of cleanliness. The fan's round shape fits perfectly in the module, ensuring even airflow through the filters we stacked inside.



**Figure 5. Testing and working of module**

The fig – 5 shows to really put the purifier to the test, we generated some smoke inside the 200 sq. ft. room; to spike the air pollution level. The smart life app helps us track the results in real-time and image shown the setup with the app open on our phone. The PM2.5 reading hit 265  $\mu\text{g}/\text{m}^3$ , which we set as our benchmark – anything above 100  $\mu\text{g}/\text{m}^3$  means the air quality is bad, and below 100  $\mu\text{g}/\text{m}^3$  means it's good. At 265  $\mu\text{g}/\text{m}^3$ , the air quality was clearly in the bad range due to the smoke, but it showed the purifier was up for the challenge. The module working properly by showing the perfect readings.



**Figure 6. Testing and working of module**

After letting the Purifier run for 10-15 Minutes, we checked the air quality again, and the result were even better. The smart life shown the PM2.5 level dropped to 56  $\mu\text{g}/\text{m}^3$  a solid improvement from the 265  $\mu\text{g}/\text{m}^3$  we started after the smoke test. Based on the benchmark, this 56  $\mu\text{g}/\text{m}^3$  reading is well within the better air quality range (below 100  $\mu\text{g}/\text{m}^3$ ) Providing the purifier can clean up a 100-300 sq. ft indoor spaces effectively.

## X. CONCLUSION

The system successfully addressed the challenges of indoor air pollution by providing an energy-efficient, affordable, and smart solution for 100-300 sq.ft. spaces. With a 78% reduction in PM2.5 levels in just 15 minutes, it proved effective for small indoor environments. Future improvements could include integrating more advanced sensors for VOC detection and enhancing the design for larger spaces.

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