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# Solar Powered Outdoor Air purifier with Air Quality Monitor

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**ABSTRACT:** The "Solar Powered Outdoor Air Purifier with Air Quality Monitor" is an innovative solution that addresses the pressing issues of urban air pollution and environmental sustainability. This cutting-edge system combines solar power technology, advanced air purification capabilities, and real-time air quality monitoring to create a self-sustaining outdoor air purification unit. This outdoor air purifier is equipped with high-efficiency photovoltaic panels that harness solar energy, eliminating the need for grid electricity. The collected solar energy powers the air purification system, making it an environmentally friendly and cost-effective solution for outdoor spaces such as parks, plazas, and urban streets. In addition to its purification capabilities, the device features an integrated air quality monitor that continuously assesses the surrounding air.

**Keywords:** Air Purifier, Solar Panel, HEPA filter, terminal, Quality Monitoring

## I. INTRODUCTION

In the face of escalating air pollution concerns, air purifiers have emerged as vital devices to enhance quality of air. This solar-powered air purifier integrates a Sensors, Filters, Arduino and other components to efficiently remove air pollutants, presenting an eco-friendly alternative. The multi-stage purification process involves pre-filtering large particles, capturing dust and smoke with the HEPA filter, and employing Carbon filtration for micro-particles. Amidst the global air pollution crisis, traditional air purifiers, despite their efficacy, often operate on electricity, contributing to higher utility bills. To address this, a cost-effective solar-powered air purifier becomes imperative. Reports revealing millions of premature deaths linked to air pollution underscore the urgency of combatting this crisis.

Existing air purifiers on the market are criticized for their inefficiency and reliance on conventional energy sources. Research by Baltrėnas et al. underscores the efficacy of negative ionic air purifiers in removing particles within confined spaces, with optimal performance observed at a height of 60cm from the ground [1]. Sundararajan's study highlights the effectiveness of HEPA and activated carbon filters in eliminating air contaminants. HEPA filters boast up to 99.97% efficiency in filtering micro-particles and disinfecting micro-organisms, while activated carbon, known for its adsorption capabilities, effectively removes sulphur compounds, albeit with efficiency variations over time [1]. Divate and Kadam's research further corroborates the superior adsorption efficiency of activated carbon compared to other filters [2]. Additionally, studies by Chakravarthy et al. [3], Bharaswadkar and Mehta [5], and Ray et al. [6] have contributed valuable insights into the design and functionality of solar-powered air purifiers with integrated air quality monitoring systems. These studies underscore the potential for real-time assessment and management of indoor and outdoor air quality, marking a significant advancement in the field [3][5][6]. Despite the increasing popularity of air purifiers, studies, such as the one involving 32 individuals exposed to air purifiers, show a significant reduction in PM2.5 concentration but fail to establish a clear link to improved respiratory health. Additional research underscores the potential health risks associated with air pollution, especially in densely populated areas [4]. For instance, a study on stable COPD patients revealed a correlation between elevated air pollutants and increased symptoms like sore throat, nausea, cough, and dyspnea, with FeH2S emerging as a potential marker for detecting adverse respiratory effects [4].

Air pollution has been associated with various adverse health effects, including respiratory ailments, Ischemic heart disease, stroke, chronic obstructive pulmonary disease (COPD), and lung cancer. The pie-chart representation is shown below,

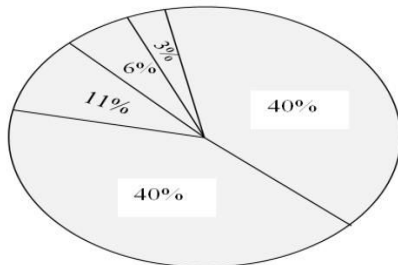


Fig. (a) Pie-chart of air borne diseases

40% - Ischemic heart disease  
 40% - Stroke  
 11% - Chronic Obstructive Pulmonary Disease (COPD)  
 6% - Lung Cancer  
 3% - Acute Lower Respiratory Infections in children

## II. RELATED WORK

In recent years, the pressing global issue of air pollution has prompted extensive research into effective mitigation strategies. Among these strategies, the utilization of HEPA filters and activated carbon filters has emerged as a promising solution for clearing airborne pollutants. Research, such as that conducted by et al, has demonstrated the remarkable efficacy of HEPA filters, boasting an impressive efficiency of up to 99.97% in filtering micro particles and disinfecting microorganisms present in the atmosphere. These findings underscore the potential of such filtration technologies in combating air pollution.

Moreover, the integration of renewable energy sources, particularly solar energy, has garnered attention as a sustainable approach to power air purification systems. The fabrication and design of solar-powered air purifiers, as highlighted in the research published in the Journal of Emerging Technologies and Innovative Research, exemplify this innovative approach. By harnessing solar energy through photovoltaic panels, these systems can operate autonomously, reducing reliance on conventional energy sources and consequently mitigating their carbon footprint. This integration of renewable energy not only enhances the sustainability of air purification efforts but also contributes to broader environmental conservation goals.

## III. METHODOLOGY

The methodology encompasses two pivotal components: monitoring and filtration. Monitoring is facilitated by a network of sensors continuously gathering real-time data on air quality. This data undergoes meticulous processing by an ESP32 microcontroller unit, ensuring accuracy and reliability, before being presented through a user-friendly interface. This interface empowers users with clear insights into the current state of their environment's air quality, enabling informed decision-making regarding ventilation adjustments or precautionary measures.

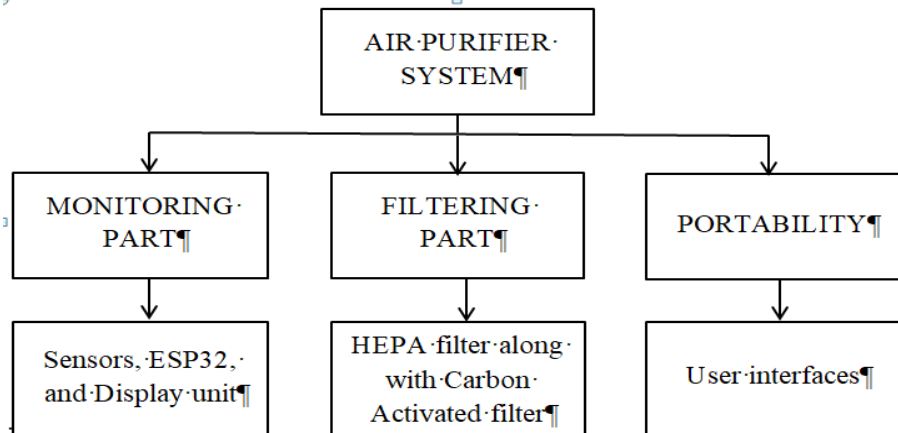


Fig. (b) Block Diagram of Air purifier System

Filtration, on the other hand, employs a robust system featuring a brushless DC fan, which efficiently draws contaminated air through a designated inlet. This air then undergoes a comprehensive three-stage filtration process. Initially, it encounters a pre-filter, adept at capturing larger dust particles and debris, thereby extending the lifespan of subsequent filters. Subsequently, the air passes through a High-Efficiency Particulate Air (HEPA) filter renowned for its ability to trap microscopic pollutants like pollen, pet dander, and airborne bacteria. Finally, the air traverses an activated carbon filter, which targets a wide array of pollutants, including harmful gases and odors. This porous filter structure facilitates the adsorption of pollutants, enhancing air quality significantly.

By seamlessly integrating monitoring and filtration functionalities, the system achieves a synergistic effect, ensuring comprehensive and effective air purification. This holistic approach not only eliminates particulate matter and pollutants but also provides users with real-time feedback on air quality, ultimately promoting healthier and more comfortable indoor environments.

#### IV. EXPERIMENTAL SETUP

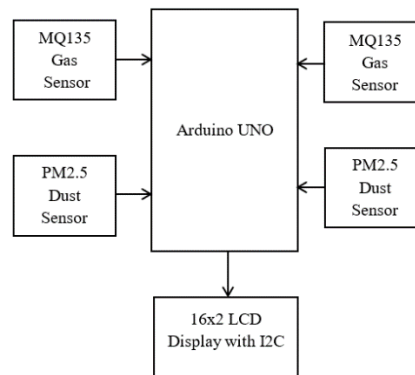


Fig. (c) Block Diagram of Monitoring Part

The air quality monitoring system comprises two key sensors: the MQ-135 dust sensor and the PM2.5 gas sensor. The MQ-135 dust sensor gauges air resistance to electric current, with increased dust particle concentration leading to higher sensor resistance. Meanwhile, the PM2.5 gas sensor targets PM2.5 particles, known for their ability to deeply penetrate the lungs and trigger respiratory issues. These sensors, integrated into the system, relay data to the Arduino UNO microcontroller, a pivotal component responsible for sensor data interpretation, processing, and LCD display control. Despite the LCD display's lack of direct I2C compatibility with the Arduino Uno, an alternative approach using a character LCD display communicating via a serial communication protocol can be adopted, leveraging the Uno's TX/RX pins compatibility. At predefined intervals, the Arduino UNO signals each sensor for data retrieval. The MQ-135 dust sensor responds by adjusting its resistance in proportion to air dust concentration, while the PM2.5 gas sensor relays signals indicating PM2.5 particle density. Subsequently, the Arduino UNO receives and converts these signals into readable data. After processing, the Arduino UNO prepares the data for presentation on the LCD screen, typically via serial communication. The LCD screen then translates this processed data into a comprehensible format, providing users with clear insights into air quality conditions.



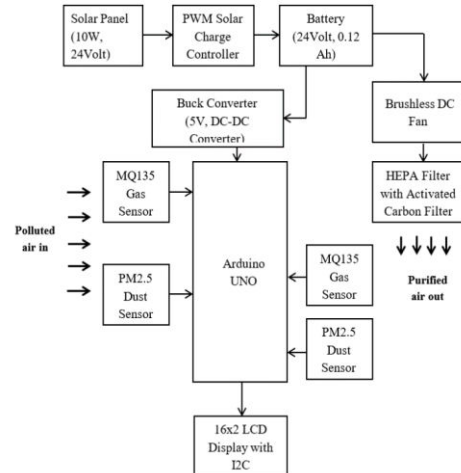
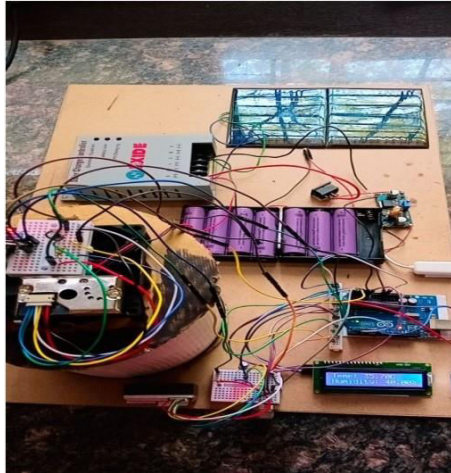


Fig. (d) Connection Diagram and Block Diagram of Solar Powered Outdoor Air Purifier and Air Quality Monitor

**Working:** The monitoring system, equipped with sensors like the Dust sensor and gas sensor, operates using an Arduino UNO to manage data from multiple sensors simultaneously. Employing Serial Communication over six analog pins, data transmission occurs efficiently and sequentially, facilitating real-time monitoring of environmental parameters. The system's output is readily accessible through an LCD display, providing users with immediate insights into air quality conditions. This comprehensive setup ensures reliability and ease of use, with the integration of Arduino UNO optimizing the monitoring process within hardware limitations. Furthermore, the system's sustainable power supply relies on a solar panel, charging a battery that powers both a brushless DC fan and the monitoring device through a buck converter. To maintain optimal battery performance and prevent reverse power flow, a solar charge controller is implemented between the solar panel and the battery. The DC fan plays a crucial role in air purification, drawing in ambient air for filtration through various stages, including HEPA and activated carbon filters. This multi-stage filtration process effectively removes particulate matter and pollutants from the air, contributing to improved indoor air quality. Overall, this monitoring system exemplifies a practical approach to environmental sensing and IoT applications, offering accurate data integration and accessibility while promoting sustainability and ease of use.

### V. EXPERIMENTAL RESULTS

Sensors	Before	After	Place of Observation
Gas Sensor	125 ppm	56 ppm	Class Room
	160 ppm	92 ppm	Corridor
	133 ppm	61 ppm	Lab
	190 ppm	110 ppm	Road Side
	260 ppm	186 ppm	Construction Site
Dust Sensor	156 mg/m <sup>3</sup>	79 mg/m <sup>3</sup>	Class Room
	198 mg/m <sup>3</sup>	122 mg/m <sup>3</sup>	Corridor
	167 mg/m <sup>3</sup>	96 mg/m <sup>3</sup>	Lab
	247 mg/m <sup>3</sup>	182 mg/m <sup>3</sup>	Road Side



	290 mg/m <sup>3</sup>	207 mg/m <sup>3</sup>	Construction Site
	Temperature	Humidity	
<b>DTH11 Sensor</b>	36.4°C	46%	Class Room
	39.6°C	39%	Corridor
	34.1°C	49%	Lab
	41.9°C	36%	Road Side
	42.3°C	34%	Construction Site

Table.1 . Readings Displayed on LCD under Different Environmental Conditions

## VI. CONCLUSION

In this prototype, our solar-powered outdoor air purifier with an air quality monitor offers a practical solution to combat air pollution in urban areas. By harnessing solar energy and employing advanced filtration technology, we can effectively remove harmful pollutants from the air while providing real-time monitoring of air quality. This system represents a sustainable and accessible approach to promoting cleaner and healthier environments for all.

## VII.FUTURE SCOPE

- 1) **Expanding Coverage Area:**
  - Researching methods to increase the effective area of a single purifier, potentially through improved fan technology or innovative air distribution designs.
  - Exploring the feasibility of developing modular purifier systems that work together to cover a larger area.
- 2) **Enhancing Weather Resilience:**
  - Investigating alternative energy sources to supplement solar power during low-light conditions, such as wind or micro-hydro options.
  - Developing more efficient solar panels and battery storage systems to maximize energy collection and storage capacity.
- 3) **Advanced Air Filtration:**
  - Researching and implementing next-generation filtration technologies that capture a broader range of pollutants, including emerging contaminants.
  - Exploring self-cleaning filter mechanisms to reduce maintenance requirements.
- 4) **Smart Features and Integration:**
  - Developing smart functionalities for the purifier, such as automatic adjustments based on real-time air quality data.
  - Integrating the air quality monitor with other smart city infrastructure to create a comprehensive air quality management system.
  - Enabling remote monitoring and control of the purifier for improved user experience.
- 5) **Cost Reduction and Scalability:**
  - Investigating methods to reduce manufacturing costs for the purifiers to make them more accessible for wider adoption.
  - Developing scalable production methods to facilitate large-scale deployment in cities and communities.



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