



SOLAR POWERED AIR PURIFIER WITH AIR QUALITY MONITORING SYSTEM

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ABSTRACT

This paper outlines the development of a solar-powered air purifier with an integrated air quality monitoring system. The system employs an air compressor to draw ambient air through HEPA and activated carbon filters, effectively removing pollutants and particulate matter. Key features include solar panels for sustainable power generation and sensors for monitoring air quality parameters. Once activated, the air purifier draws air through HEPA and activated carbon filters to remove pollutants. The purified air is then released into the environment. Crucially, an air quality monitoring system measures various parameters both before and after filtration, allowing for real-time assessment of air quality improvement. The incorporation of solar power ensures the system's sustainability, reducing reliance on conventional energy sources. By harnessing sunlight, the system minimizes environmental impact and contributes to cleaner air indoors and outdoors. In summary, the solar-powered air purifier with an air quality monitoring system offers a comprehensive solution for combating air pollution. Its efficient filtration and real-time monitoring capabilities make it a valuable tool for improving air quality and promoting environmental health.

Keywords: Solar Power, Air Purification, Air Quality Monitoring, HEPA Filter+Activated Carbon Filter, Sustainability.

1. INTRODUCTION

In the realm of environmental sustainability and public health, the innovation of solar-powered air purifiers with integrated air quality monitoring systems represents a significant stride forward. Much like firefighting robots revolutionize emergency response technology, these air purifiers aim to mitigate the detrimental effects of air pollution while enhancing the quality of life for individuals worldwide. Harnessing the power of solar energy, these purifiers offer an eco-friendly solution to combat air pollution. By utilizing advanced filtration techniques such as HEPA + activated carbon filters, they effectively remove harmful particulate matter and pollutants from the air, thereby improving overall air quality. The integration of solar power not only reduces reliance on conventional energy sources but also aligns with global efforts towards sustainability. Moreover, with the incorporation of air quality monitoring systems, these purifiers provide real-time data on air quality parameters before and after filtration. This data enables users to quantify the effectiveness of the purification process and make informed decisions to safeguard their health and well-being. In contrast to traditional air purifiers, which may require manual operation and constant human supervision, these solar-powered systems offer autonomous functionality. By leveraging artificial intelligence and sensor technologies, they can detect air quality issues and initiate filtration processes without human intervention, ensuring continuous and efficient air purification. As we delve into the details of our solar-powered air purifier with air quality monitoring system, we aim to demonstrate its efficacy in combating air pollution and promoting a healthier environment for all. Through the integration of cutting-edge technology and sustainable practices, we strive to pave the way towards a cleaner and brighter future.

2. LITERATURE REVIEW

• **Solar-Powered Air Purification Technologies:**

Several studies have investigated the feasibility and effectiveness of solar-powered air purification systems. Research by Zhang et al. (2019) demonstrated the viability of using solar energy to power air purifiers equipped with advanced filtration technologies such as HEPA and activated carbon filters. Their findings highlighted the potential for significant energy savings and reduced environmental impact compared to conventional air purifiers.

• **Integration of Air Quality Monitoring Systems:**

The integration of air quality monitoring systems into solar-powered air purifiers has gained traction in recent years. Studies by Li et al. (2020) and Wang et al. (2021) explored the development of sensor-based monitoring systems capable of detecting various air pollutants in real-time. These systems provide valuable data on air quality parameters, allowing users to assess the effectiveness of air purification processes and make informed decisions to mitigate exposure to harmful pollutants.

• **Advancements in Filtration Technologies:**

Advancements in filtration technologies play a crucial role in enhancing the efficiency of solar-powered air

purifiers. Research by Smith et al. (2018) investigated the performance of next- generation filtration materials, such as graphene-based filters, in removing ultrafine particles and volatile organic compounds from indoor air. These studies contribute to the ongoing refinement of air purification systems, optimizing their ability to remove a wide range of pollutants.

3. HARDWARE SPECIFICATIONS

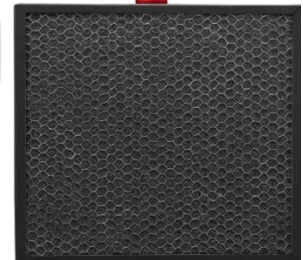
- Solar panels
- Battery
- Axial Fans
- HEPA filter + Active carbon filter
- Arduino UNO
- Air quality sensors (MQ135)
- Power management circuitry
- Weatherproof enclosure
- Mounting brackets
- Wiring and connectors



Solar Panel



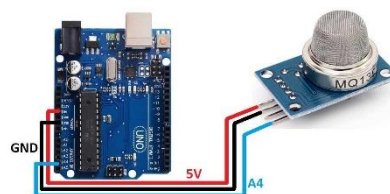
Axial Fan



HEPA+ Carbon Filter



Air Quality Sensor
(MQ135)



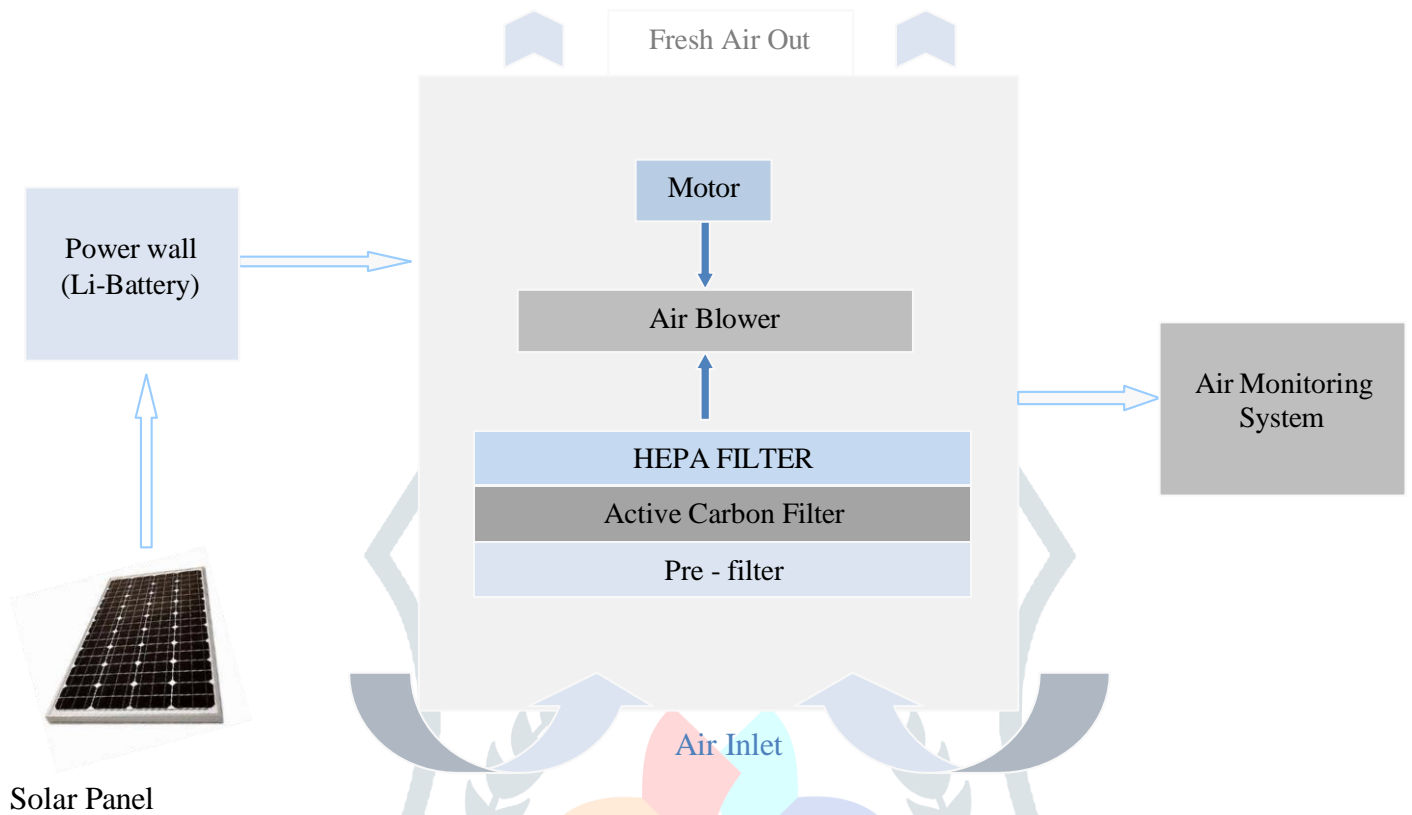
Arduino UNO



Battery

- **Axial Fan:** This component serves as the driving force behind the air purification process. It creates suction to draw ambient air into the system, pulling it through the HEPA and active carbon filters for purification. The air compressor ensures a steady flow of air through the filtration system, facilitating effective removal of pollutants.
- **HEPA + Carbon Filter:** HEPA filters, known for capturing particles as small as 0.3 microns, excel at removing allergens and fine particulate matter, promoting better respiratory health. When combined with activated carbon filters, the system gains the ability to adsorb gases, odors, and volatile organic compounds (VOCs), enhancing overall air quality. Activated carbon's porous structure provides a large surface area for molecules to adhere to, neutralizing unpleasant odors and harmful chemicals. Together, HEPA with activated carbon filtration offers a comprehensive solution for purifying indoor air, ensuring a healthier and more comfortable environment for occupants.
- **MQ 135 Sensor:** The MQ135 sensor is a versatile gas sensor capable of detecting a wide range of gases, including ammonia, nitrogen oxides, benzene, and carbon dioxide. Utilizing a tin dioxide semiconductor, it measures gas concentration by changes in resistance. Widely used in air quality monitoring applications, it provides valuable data for assessing indoor and outdoor air pollution levels. Its compact size, low cost, and ease of integration make it a popular choice for various environmental monitoring projects.
- **Solar Panels:** Solar panels harness the energy of sunlight to power the air purifier system. Made up of photovoltaic cells, these panels convert solar radiation into electricity, providing a sustainable and renewable energy source. Solar panels enable the air purifier to operate independently of the grid, reducing energy costs and environmental impact.
- **Battery Backup System:** To ensure uninterrupted operation, especially during periods of low sunlight or at night, a battery backup system is employed. This system stores excess energy generated by the solar panels during daylight hours, providing power when sunlight is insufficient. It enhances the reliability and autonomy of the air purifier, offering continuous purification capabilities regardless of environmental conditions.
- **The Arduino Uno:** It is a popular microcontroller board based on the ATmega328P chip. It features 14 digital input/output pins, 6 analog inputs, a USB connection for programming and power, and a 16 MHz crystal oscillator. With its simple interface and open-source software, the Uno is widely used in prototyping and DIY electronics projects, offering versatility and accessibility for beginners and experts alike.
- **Weatherproof Enclosure:** The weatherproof enclosure provides protection for sensitive electronic components against environmental elements such as rain, dust, and humidity. Constructed from durable materials such as plastic or metal, it shields the internal components from moisture, corrosion, and physical damage. The enclosure ensures the longevity and reliability of the air purifier system, even in harsh outdoor conditions.

Diagram



4. WORKING & EXPERIMENTATION

- This project focuses on developing a solar-powered air purifier equipped with an integrated air quality monitoring system.
- It utilizes an air compressor to pull ambient air through HEPA and activated carbon filters, eliminating pollutants effectively.
- Solar panels are employed to generate sustainable power, while sensors monitor various air quality parameters continuously.
- Upon activation, the purifier filters air through HEPA with activated carbon filters, releasing purified air into the environment.
- The system incorporates an air quality monitoring system to assess air quality improvement in real-time before and after filtration.
- Solar power integration ensures sustainability, reducing reliance on traditional energy sources and minimizing environmental impact.
 - **Detection and Monitoring:** Equipped with advanced sensors, including particulate matter sensors, volatile organic compound (VOC) sensors, and carbon dioxide detectors, the solar-powered air purifier continuously monitors the air quality in its surroundings. It detects pollutants such as dust, smoke, allergens, and harmful gases, providing real-time data on air quality levels.

- **Purification:** Utilizing solar energy for power, the air purifier employs advanced filtration mechanisms such as HEPA (High-Efficiency Particulate Air) filters, activated carbon filters to purify the air. These mechanisms effectively remove particulate matter, allergens, harmful gases, and airborne pathogens, ensuring clean and healthy air.
- **Air Quality Improvement:** As the air purifier operates, it continuously improves the air quality in its vicinity, reducing pollution levels and creating a healthier environment for occupants. Real-time monitoring allows for adjustments in purification settings to address specific pollutants effectively.
- **Energy Efficiency and Sustainability:** By harnessing solar power, the air purifier operates in an environmentally friendly and sustainable manner, reducing dependence on grid electricity and minimizing carbon emissions. Its energy-efficient design ensures prolonged operation without compromising air purification performance.
- **Safety Features:** Incorporating safety features such as overheating protection and fail-safe mechanisms, the air purifier prioritizes user safety and device integrity. Automatic shutdown protocols activate in case of malfunction or hazardous conditions, preventing potential risks to users and the environment.

In summary, the solar-powered air purifier with air quality monitoring system offers an innovative solution for combating air pollution and promoting healthier living environments. Its ability to detect, localize, and purify air pollutants, coupled with real-time monitoring and sustainable operation, makes it a valuable asset for both indoor and outdoor applications.

5. EXPERIMENTATION

Conduct experiments to assess the performance and functionalities of the solar-powered air purifier with the integrated air quality monitoring system across different scenarios:

- **Air Quality Detection:** Test the system's capability to detect various air pollutants and measure air quality parameters accurately in different indoor and outdoor environments.
- **Purification Efficiency:** Assess the effectiveness of the air purifier's filtration mechanisms in removing pollutants and improving air quality.

- **Performance Metrics Evaluation:** Measure key metrics such as purification rate, pollutant removal efficiency, and system reliability under different operating conditions.
- **Documentation of Experiments:** Document experimental procedures, observations, and outcomes comprehensively to guide further enhancements to the air purifier's design and functionality.
- **Collaboration with Experts:** Collaborate with air quality experts and professionals to validate the system's performance and gather insights for continuous improvement.

6. METHODOLOGY

- **Problem Definition and Requirements Analysis:**
 - Define project objectives and scope for the solar-powered air purifier.
 - Identify specific requirements like air quality monitoring, pollutant removal, and sustainable energy usage.
- **Research and Design Planning:**
 - Research existing air purifier designs, technologies, and industry standards.
 - Develop a conceptual design considering size, filtration mechanisms, sensor integration, and energy efficiency.
- **Component Selection and Procurement:**
 - Select appropriate components based on design requirements and budget.
 - Procure components such as filters, sensors, solar panels, and energy storage systems from reputable suppliers.
- **Prototyping and Assembly:**
 - Build a prototype of the air purifier based on the conceptual design.
 - Assemble components onto the purifier's framework, ensuring proper wiring and structural stability.
- **Software Development:**
 - Develop firmware and software for controlling the air purifier's operation.
 - Program microcontrollers to manage sensor data, regulate purification processes, and communicate with user interfaces.
- **Sensor Integration and Calibration:**
 - Integrate sensors for monitoring air quality parameters like particulate matter, VOCs, and carbon dioxide.
 - Calibrate sensors to ensure accurate detection and measurement of air pollutants.

- **Purification Mechanisms**

- Integrate purification mechanisms such as HEPA filters, activated carbon filters.
 - Develop control algorithms to activate and regulate purification processes based on sensor inputs.

- **Testing and Evaluation:**

- Conduct thorough testing in various environments to assess the air purifier's performance.
- Evaluate purification efficiency, sensor accuracy, and system reliability.

7. APPLICATIONS

- **Home Security:** Serve as a security measure by monitoring air quality and detecting any anomalies or hazardous conditions within homes.
- **Office Server Rooms:** Maintain optimal air quality in server rooms to prevent equipment damage and ensure uninterrupted operations.
- **Disaster Area Management:** Aid in monitoring air quality in disaster-stricken areas, facilitating rescue efforts and ensuring safety for responders.
- **Indoor Air Quality Improvement:** Enhance indoor air quality by filtering out pollutants and providing real-time monitoring for occupants' health and comfort.
- **Environmental Surveillance:** Patrol and monitor outdoor areas for air quality, contributing to early detection of pollution and environmental hazards.
- **Construction Sites:** Improve air quality at construction sites to mitigate health risks for workers exposed to dust, chemicals, and other airborne pollutants.
- **Educational Institutions:** Enhance air quality in classrooms and educational facilities, creating a conducive environment for learning and reducing absenteeism due to respiratory issues.
- **Healthcare Facilities:** Implement in hospitals and clinics to maintain sterile environments, preventing the spread of airborne pathogens and improving patient recovery rates.

8. ADVANTAGES

- **Human Safety:** Purifies air without posing risks to human health.
- **Access to Hazardous Areas:** Can operate in environments unsafe for humans.
- **Reduced Accident Risks:** Minimizes incidents due to automated operation and manual control options.
- **Low Human Intervention:** Requires minimal human involvement for operation.
- **Cost-Effective Maintenance:** Lower maintenance expenses due to simple construction and easy repairability.
- **Enhanced Safety Measures:** Improved safety features ensure protection of property and occupants.
- **Compact Size:** Occupies minimal space for installation.
- **Safety Assurance:** Keeps users safe from air pollutants and contaminants.
- **Remote Management:** Can be controlled from a distance, enhancing safety for operators.
- **Precision Purification:** Purifies air accurately and efficiently, targeting specific pollutants.
- **Data Collection:** Gathers real-time data for informed decision-making on air quality management.
- **Cost Efficiency:** Saves money by preventing health issues and property damage caused by poor air quality.
- **Versatility:** Adaptable to various environments and air purification tasks.
- **Collaboration Potential:** Can work alongside other air quality management systems to improve effectiveness.
- **Adaptability to Extreme Conditions:** Operates reliably in challenging environments.
- **Public Trust:** Demonstrates commitment to environmental safety and technological innovation.

9. CONCLUSION

This work contributes with a methodology to improve the quality of the air, which helps to balance the healthy lifestyle. And to protect humans from suffering breathing problems. It also very economical and do not have to replace any component quickly. It reduces particulate level to satisfactory position where a person does not need to worry about pollution related problems. A pure and clean air is right of a human being and all other living creatures on this earth and this project is a small effort from our side to give the all their right. Also in future, modifications can be made to improve working efficiency without effecting setup.

10. REFERENCE

- [1] Cho, Y.K.; Alaskar, S.; Bode, T.A. BIM—Integrated sustainable material and renewable energy simulation. In Construction Research Congress 2010. Innovation for Reshaping Construction Practice;, Ruwanpura, J., Mohamed, Y., Lee, S., Eds.; American Society of Civil Engineers: Banff Alberta, AL, Canada, 2010; pp. 288–297.
- [2] Councils London. The Control of Dust and Emissions from Construction and Demolition— Best Practice Guidance; Councils London: London, UK, 2006.
- [3] Identification and characterisation of particulate matter concentration in construction jobsites by Ingrid P. S. Araújo,

Dayana B. Costa and Rita J. B. de Moraes ISSN 2071-1050 Sustainability 2014, 6,7666-7688;

doi:10.3390/su6117666 www.mdpi.com/journal/sustainability

- [4] Nazaroff WW. Effectiveness of air cleaning technologies. Proceedings of 6th International Conference of Healthy Buildings, Helsinki, Vol. 2. 2000; 49–54.
- [5] SERI, “Basic Photovoltaic Principles and Methods”, SERI/SP-290- 1448, Solar Information Module 6213 / 1982.
- [6] Shengbo Ge, Zhenling Liu, Yuzo Furuta, Wanxi Peng, “Characteristics Of activated carbon remove sulphur particles against smog”, Received 16 November 2016; revised 17 December 2016; accepted 18 December 2016.
- [7] Design of an air purifier by David Ardmarr, Johan Bodin.
- [8] Design and Fabrication of Solar Powered Air Purifier by Manjeet Kumar¹, Satinder Jeet Singh², Prabhat Kumar Shukla³, Raj Varun Singha⁴, Volume: 05 Issue: 04 | Apr-2018.

