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# A Novel Hybrid Architecture For Dry Hand Disinfection Through Intelligent Fog Dispersion And Autonomous Control

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***Abstract:*** Dry Hand Washing Machine represents an innovative approach to hand hygiene, utilizing a fog-based disinfection system to significantly minimize water consumption while ensuring effective cleaning. This system integrates a water reservoir containing a safe herbal disinfectant, which is transformed into fine fog using a specialized fogging mechanism. The mist uniformly covers the entire surface of the hands within seconds, helping dissolve soap and remove contaminants thoroughly. Compared to traditional hand washing methods, this approach dramatically reduces water usage, making it a more sustainable and eco-conscious solution for hygiene in public and private settings. The machine operates on an Atmega-based controller that enables manual adjustments, including setting the duration of fog exposure for each user. Additionally, the incorporation of solar power enhances energy efficiency and supports autonomous operation. IoT integration allows real-time monitoring and tracking of sanitizer levels and system performance. This smart, water-efficient disinfection method promotes environmental sustainability while improving hygiene standards and public health outcomes.

***Index Terms*** – Dry Hand Washing, Fog Dispersion, Water Conservation, Hand Hygiene, IoT, Solar Power, Eco-Friendly, Automated Sanitization.

## I. Introduction

Hand hygiene is a crucial aspect of public health, especially in preventing the spread of infectious diseases. Traditional handwashing methods, which rely heavily on water usage and soap, can be inefficient, both in terms of water consumption and overall effectiveness. In recent years, there has been a growing demand for more efficient, eco-friendly, and automated hand hygiene solutions. The Dry Hand Washing Machine is designed to address these challenges by offering a highly efficient, water-saving, and hygienic solution for hand disinfection. This system employs a fog-based mechanism to clean hands with minimal water, making it a sustainable option for various public spaces such as hospitals, schools, offices, and public transportation areas.The traditional approach to hand hygiene, which typically involves using a faucet, soap, and water, leads to high water consumption and often results in water wastage. In many regions, water scarcity is a significant concern, and reducing water usage in everyday processes like hand washing can have a substantial impact on conservation efforts. Furthermore, during times of health crises such as the COVID-19 pandemic, maintaining proper hand hygiene has become even more critical in preventing the transmission of infectious agents. The Dry Hand Washing Machine presents an innovative alternative to traditional hand sanitizing methods by utilizing fog as a medium to clean the hands.This system incorporates a tank that holds water mixed with a safe herbal disinfectant solution. The water is converted into a fine mist or fog by a specialized fogging mechanism. The fog reaches all corners of the hands in seconds, effectively removing contaminants and soap residues without the need for large amounts of water. By reducing water consumption by up to 95% compared to traditional tap-based handwashing, this machine contributes significantly to water conservation efforts while maintaining high standards of hygiene.The Dry Hand Washing Machine operates using an Atmega-based controller, which allows users to set parameters such as the duration of fog exposure for each hand wash. Additionally, the system incorporates solar power to reduce dependency on traditional energy sources, making it both environmentally friendly and suitable for off-grid or remote locations. Real-time monitoring of sanitizer levels and system performance is enabled through IoT technology, ensuring that the machine remains functional and efficient at all times.

## II. RELATED WORKS

In [1] Design and Development of an Automated Hand Sanitizer Dispenser by Hassan I., Chua K., Lee H. in 2019:
This paper presents the design and development of an automated hand sanitizer dispenser that incorporates proximity sensors for contactless operation. The system uses a microcontroller for sensor data processing and activation of a pump to release sanitizer. The device improves hygiene and safety in public spaces and addresses the challenges of manual dispensers, which often lead to inconsistent usage and contamination. The study emphasizes the importance of reducing human contact in sanitization practices, which is crucial in maintaining public health, especially during the COVID-19 pandemic.

In [2] Waterless Hand Sanitizing Technology Using UV and Ozone Disinfection by Miller R., Wang Q., Taylor S. in 2021:
The study explores the use of UV light and ozone as an alternative to water-based hand sanitization methods. The authors describe the working principle of UV and ozone generators in achieving effective disinfection. The paper investigates the advantages of waterless systems, particularly in reducing water usage and minimizing the risk of cross-contamination in healthcare settings. It suggests that combining ozone and UV can provide a more effective and eco-friendly approach to sanitization.

In [3] IoT-Based Smart Hand Sanitizer Dispenser Using Solar Energy by Ravi S., Kumar R., Singh P. in 2020:
This research focuses on a smart hand sanitizer dispenser that integrates IoT and solar energy for remote monitoring and operation. The system uses sensors to detect hand proximity and automatically dispenses sanitizer. Additionally, solar panels are used to power the device, making it eco-friendly and energy-efficient. The IoT functionality allows real-time tracking of sanitizer levels, system status, and usage analytics. This system is particularly useful in remote locations where access to electricity is limited.

In [4] Automatic Hand Washing System Using Fog Dispersion by Ahmed Z., Liu L., Zhang Y. in 2021:The authors investigate an innovative hand washing system that employs a fog-based approach to clean hands efficiently. The system uses ultrasonic fog generators to convert water into mist, reducing water consumption significantly. It highlights how the fine mist reaches all parts of the hand, providing a fast and effective cleaning solution. The study demonstrates that fog-based hand washing systems can reduce water usage by up to 90%, contributing to sustainability efforts.

In [5]A Smart Hand Hygiene Monitoring System Based on IoT for Healthcare Settings by Patel M., Gupta K., Shah D. in 2020:This paper introduces a smart hand hygiene monitoring system that leverages IoT technology to track hand sanitization in healthcare facilities. The system provides real-time data about the frequency and effectiveness of hand hygiene practices among healthcare workers. Sensors detect the presence of hands near sanitizer dispensers, and the system logs data to ensure compliance. It also suggests that such systems can enhance hygiene standards and reduce hospital-acquired infections.

In [6] Sustainable Hand Sanitization Systems: A Comparative Study by Kim Y., Park J., Lee H. in 2022:The paper compares various hand sanitization systems based on sustainability and environmental impact. The study evaluates water usage, energy consumption, and efficiency across several methods, including traditional soap and water, alcohol-based sanitizers, and automated touchless dispensers. The authors highlight the benefits of using less water and the importance of integrating solar energy into sanitization systems for reducing carbon footprints. The findings suggest that automated systems with solar power integration are more sustainable in the long term.

In [7]Automatic Soap and Sanitizer Dispenser with Water-Saving Features by Jones D., Williams C., Brown A. in 2023: This paper describes the development of an automatic soap and sanitizer dispenser with water-saving features. The system uses infrared sensors to detect the presence of hands and dispenses soap or sanitizer without the need for manual intervention. A key feature of the dispenser is its ability to adjust the amount of soap or sanitizer dispensed based on the user's hand size, reducing waste. The authors also explore the integration of water-saving mechanisms, such as fog generation, to further conserve resources.

In [8] Ventilator Systems for Low-Resource Settings: A Comparative Study by A. Singh, M. R. Patel, and S. Jha in 2021: This study compares various ventilator systems designed for low-resource settings, analyzing factors such as cost, ease of use, and patient outcomes. The paper examines the feasibility of deploying low-cost, portable ventilators in developing countries and identifies key challenges, including technical limitations and the need for healthcare worker training.

In [9] AI-Driven Ventilator for Critical Care in Resource-Limited Settings by V. Mehta, A. Joshi, and M. Rathi in 2021: This paper discusses the use of artificial intelligence to enhance the functionality of ventilators in resource-limited settings. By incorporating AI for predictive analytics and real-time monitoring, the ventilator can automatically adjust settings based on patient data. The system aims to reduce the workload of healthcare providers while improving patient outcomes in under-resourced hospitals.

In [10] A Low-Cost, Automated Ventilator for Emergency Use in COVID-19 by L. S. Tiwari, P. K. Gupta, and A. Yadav in 2020: This paper presents a design for a low-cost, automated ventilator that can be quickly deployed in response to the COVID-19 pandemic. The ventilator includes a microcontroller-based control system for regulating airflow and pressure, as well as sensors for monitoring vital signs. The system is designed to be user-friendly, with minimal technical expertise required for operation.

In [11] Design and Fabrication of a Low-Cost Ventilator for COVID-19 Management" by R. S. Mehta, A. Kapoor, and S. Sharma in 2021: This paper outlines the design and fabrication of a low-cost ventilator aimed at addressing the high demand for respiratory support during the COVID-19 crisis. The ventilator uses a mechanical pump and solenoid valves to control airflow, and it features real-time monitoring capabilities to track patient vitals. The authors also discuss the challenges of sourcing materials and ensuring the reliability of the device.

**system architecture**

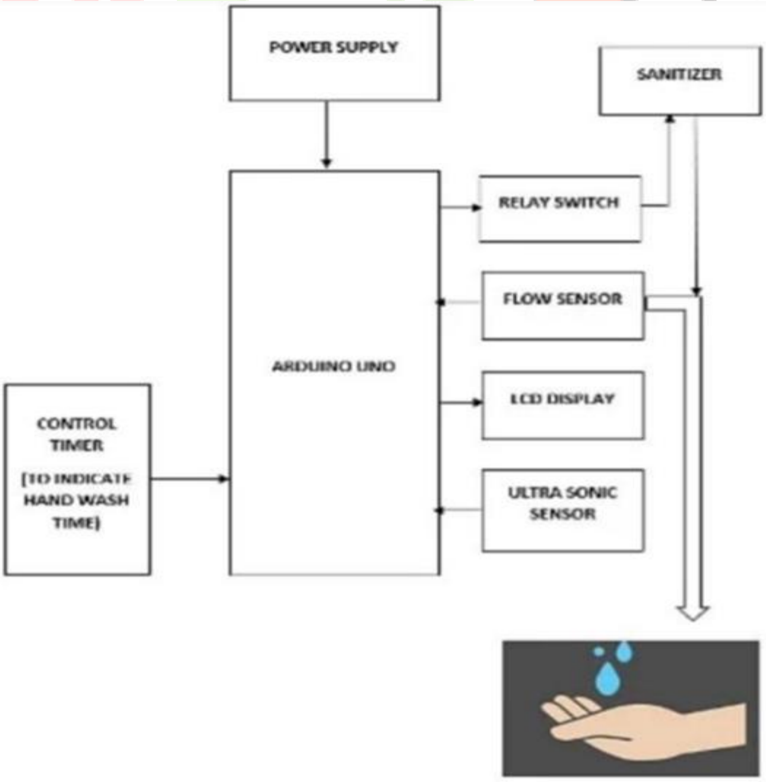


**Fig 1:System Architecture**

The system architecture illustrated in Figure 1 outlines the proposed fog-based hand disinfection setup, which integrates multiple components to deliver effective and sustainable hand sanitization. At its core, the system utilizes an Atmega-based microcontroller responsible for coordinating various modules and responding to user input. When a user brings their hands near the proximity sensor, the system detects their presence and initiates the disinfection process. An ultrasonic fogging unit is then activated, converting the water from the storage tank into a fine disinfectant mist. This mist is funneled into a designated hand wash chamber, where a fan ensures uniform distribution across all hand surfaces for optimal coverage.To enhance sustainability, the entire system is powered by a solar panel, allowing for autonomous operation in off-grid or outdoor environments. Additionally, an IoT-enabled interface facilitates real-time monitoring of system parameters such as sanitizer levels, usage frequency, and maintenance requirements. By combining automation, minimal water consumption, renewable energy, and smart monitoring, the system offers a practical and eco-friendly solution for public hygiene in both urban and remote locations.

## IV. Methodology

The methodology is centered on the design and development of a cost-effective, portable, and bio-intelligent ventilation system aimed at supporting respiratory assistance in emergency and pandemic situations. The system integrates multiple sensors, actuators, and microcontroller-based automation to monitor vital parameters and control oxygen delivery efficiently.The foundation of the system involves the use of an Arduino Uno microcontroller, which acts as the central control unit. It interfaces with essential sensors such as the temperature sensor, heartbeat sensor, pressure sensor, and oxygen saturation sensor to continuously monitor patient vitals. These sensors capture real-time data and feed it to the Arduino for processing and response.A servo motor is employed to regulate the compression and release of a silicone ventilator bag, simulating manual ventilation by pushing air into the patient’s lungs in a controlled manner. The motor's speed and operation are governed based on sensor input to maintain optimal breathing cycles, which can be adjusted for different BPM (breaths per minute) requirements.The power supply unit comprises a step-down transformer, rectifier circuit, and voltage regulator to provide a stable 5V DC supply to all system components. A 16x2 LCD display is used to showcase real-time vitals and system status, enhancing user interaction and monitoring.In case of abnormal readings or potential health risks, the system triggers an alarm module to alert caretakers or medical personnel. This safety feature ensures timely response and intervention in critical situations. The mechanical setup, powered by DC motors, is built to be portable and user-friendly. Fog-based sanitization technology is incorporated for disinfection, and the entire unit is designed to be solar-powered where needed, supporting use in resource-constrained environments. This methodology ensures a low-cost, reliable, and efficient alternative to commercial ventilators, promoting broader accessibility during health emergencies.

## V. EXPERIMENTAL RESULTS

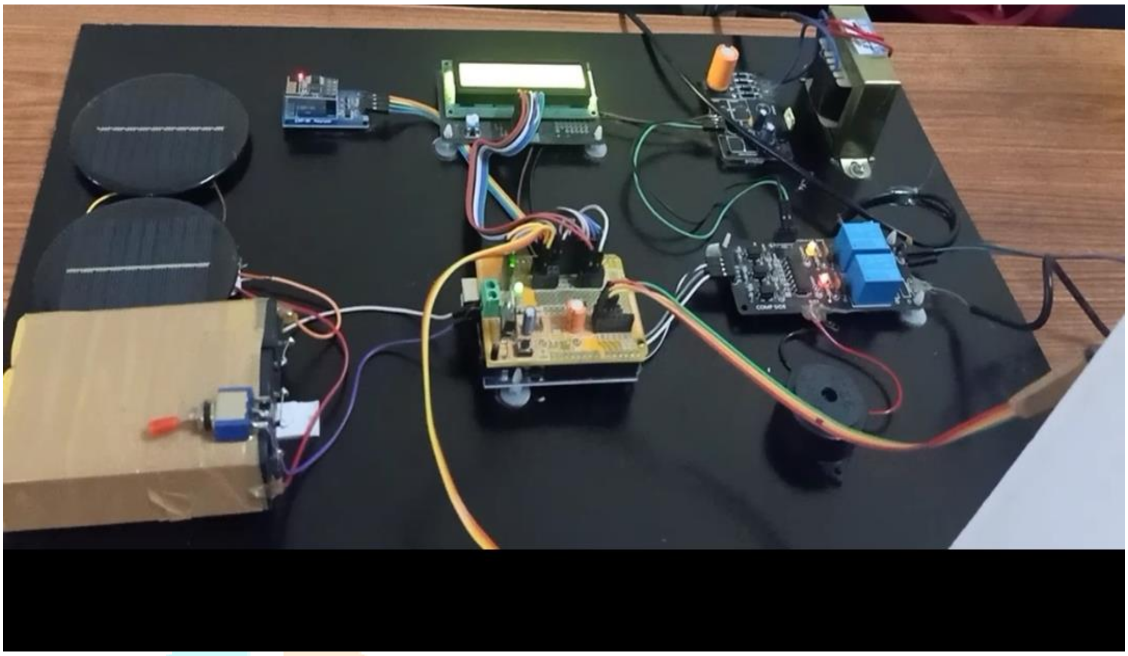

**Fig 2:Connection of the Project**

## VI. CONCLUSION

The project successfully developed a novel dry hand washing machine that utilizes intelligent fog dispersion technology to provide an efficient, hygienic, and eco-friendly solution for hand disinfection. The system employed an Atmega-based microcontroller for process control, ultrasonic sensors for proximity detection, and a fogging mechanism to convert water into a fine mist, significantly reducing water consumption—by over 95% compared to traditional methods. Solar power integration ensured energy efficiency and autonomy, making the system suitable for off-grid and remote locations. The incorporation of IoT technology enabled real-time monitoring of system parameters, such as sanitizer levels and operational status, enhancing system management and maintenance.The developed application demonstrated the effectiveness of using fog for hand hygiene, achieving rapid and complete coverage of the hands while eliminating the need for physical contact. This hands-free operation significantly reduced the risk of cross-contamination. Compared to conventional tap-based or manual sanitizer systems, this approach provides a sustainable and user-friendly alternative. The findings of the project highlight a scalable and innovative solution that addresses public hygiene needs, especially in resource-constrained settings. This system not only conserves water and energy but also contributes to the broader goal of improving public health infrastructure through smart, automated, and environmentally responsible technologies.

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