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Integrated Electrostatic Fog-Based Water Generation, Purification, and Air Quality Enhancement System

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ABSTACT

The proposed Integrated Electrostatic Fog-Based Water Generation, Purification and Air Quality Enhancement System is an innovative environmental solution designed to address water scarcity and air pollution simultaneously. The system uses electrostatic technology to attract and collect tiny water droplets present in fog and humid air for freshwater generation. The collected water is then passed through multiple purification stages such as filtration and UV treatment to ensure safe and clean water output. In addition to water harvesting, the system improves surrounding air quality by removing dust particles, pollutants, and suspended impurities from the atmosphere during operation. The project is energy-efficient, eco-friendly, and suitable for rural, urban, and industrial applications where clean water and fresh air are essential. This integrated approach provides a sustainable solution for future environmental and public health challenges.

I.INTRODUCTION

The Integrated Electrostatic Fog-Based Water Generation, Purification and Air Quality Enhancement System is designed to produce clean water from fog and humid air using electrostatic technology. The system collects microscopic water droplets from the atmosphere and purifies them through filtration and sterilization processes to obtain safe water. At the same time, it improves air quality by removing dust, smoke, and harmful airborne particles during operation. This project offers an eco-friendly and energy-efficient solution for both water scarcity and air pollution problems. The system can be effectively used in rural, urban, coastal, and industrial areas for sustainable environmental management

.II.PROBLEM STATEMENT

The increasing shortage of clean drinking water and rising air pollution are major environmental challenges in many urban and rural areas. Conventional water sources are becoming insufficient due to climate change, population growth, and contamination. In fog-prone regions, atmospheric moisture remains largely unused despite its potential as a sustainable water source. Existing fog collection systems often suffer from low efficiency and poor water quality. There is a need for an advanced system that can efficiently harvest water from fog, purify it, and simultaneously improve surrounding air quality. Therefore, an integrated electrostatic fog-based water generation, purification, and air quality enhancement system is proposed to provide a sustainable and eco-friendly solution

III. OBJECTIVES

To develop an integrated electrostatic fog-based system that can collect water from fog and humid air efficiently using electrostatic principles.

To purify the collected water and improve surrounding air quality by removing dust particles and harmful pollutants from the atmosphere.

To create an eco-friendly, low-energy, and sustainable solution for providing clean water and cleaner air in water-scarce and polluted regions.

The main objective of the proposed system is,

- To collect and generate water from atmospheric fog using electrostatic fog harvesting technology.
- To purify the harvested water and make it suitable for safe usage.
- To improve air quality by reducing dust particles and pollutants in the surrounding environment.

IV. METHODOLOGY

The integrated electrostatic fog-based water generation, purification, and air quality enhancement system works by collecting moisture from fog using an electrostatic fog harvesting mechanism. In this process, tiny fog droplets present in the atmosphere are electrically charged and attracted toward a specially designed mesh or collection surface, which improves water harvesting efficiency. The collected droplets combine to form larger water droplets and are directed into a storage tank. The harvested water then passes through multiple purification stages such as sediment filtration, activated carbon filtration, and UV sterilization to remove impurities, microorganisms, and harmful particles. During the collection process, dust and airborne pollutants are also trapped, which helps in improving surrounding air quality. Sensors are used to monitor humidity, water level, and system performance, while the entire setup operates with low power consumption and can also be integrated with solar energy for sustainable operation.

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V. BLOCK DIAGRAM

I. CIRCUIT DIAGRAM

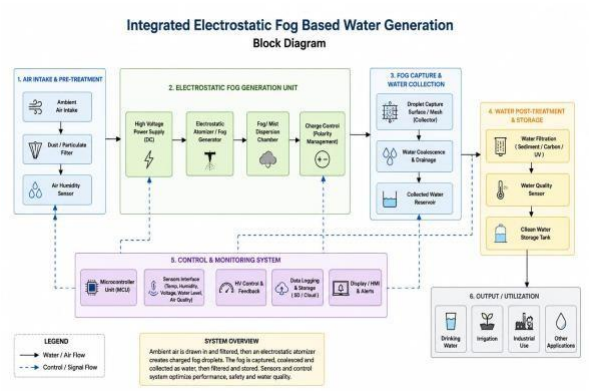

Fig 5 : Block Diagram of the proposed system

The block diagram of the Integrated Electrostatic Fog Based Water Generation, Purification and Air Quality Enhancement System shows the complete working process of the project in a simple manner. The system starts with the fog collection unit, which captures moisture particles present in the air. The electrostatic collector applies an electric field to attract and collect tiny water droplets more efficiently. The collected water is then sent to the filtration and purification unit to remove dust, pollutants, and harmful particles. After purification, the clean water is stored safely in a storage tank for usage. An air quality enhancement unit helps in reducing airborne impurities and improving surrounding air conditions. The power supply unit provides electrical energy to operate all system components continuously. Finally, the control unit monitors and manages the operation of the entire system for efficient water generation and purification.

VI. WORKING OF THE PROPOSED SYSTEM

The proposed Integrated Electrostatic Fog-Based Water Generation, Purification and Air Quality Enhancement System works by collecting moisture from foggy air and converting it into clean usable water. First, the intake fan draws fog and humid air into the system. An electrostatic fog collector creates an electric field that attracts tiny water droplets and improves fog harvesting efficiency. The collected droplets are stored in a collection chamber and then passed through multiple purification stages such as sediment filtration, activated carbon filtration, and UV sterilization to remove dust, microbes, and harmful particles. At the same time, the air purification unit filters airborne pollutants and improves indoor air quality. Finally, the purified water is stored in a clean tank for usage, while the system continuously monitors performance using sensors and a control unit.

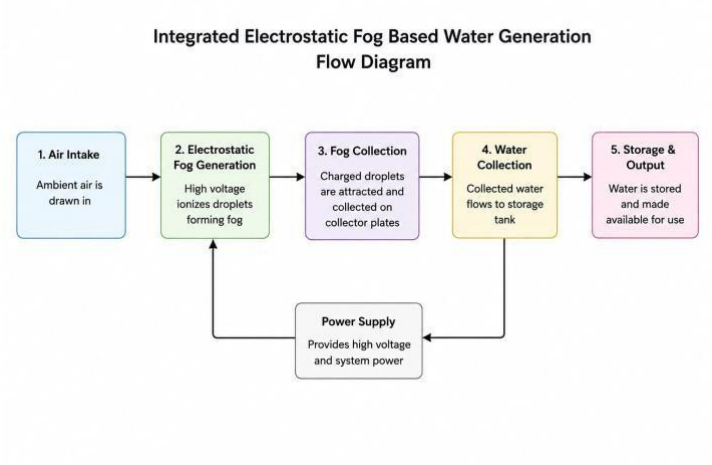

Fig : Flow chart of the Proposed system

VII. HARDWARE IMPLEMENTATION

- Air Intake Unit

A fan or blower is used to draw humid atmospheric air into the system for processing.

- Electrostatic Fog Generation Unit

High-voltage electrodes create an electrostatic field that converts water particles into charged fog droplets.

- Fog Collection Chamber Charged droplets are attracted towards collector plates where water droplets combine and settle.
- Water Purification Unit

The collected water passes through filters such as carbon or UV purification to improve water quality.

- Storage Tank Purified water is stored in a water tank for domestic or industrial use.
- Control and Monitoring System

A microcontroller with sensors monitors humidity, voltage, airflow, and water level for efficient operation.

VIII. SOFTWARE IMPLEMENTATION

The software implementation of the proposed Integrated Electrostatic Fog Based Water Generation, Purification, and Air Quality Enhancement System is designed to automate and monitor the complete operation of the system efficiently. The system is controlled using a microcontroller such as Arduino or ESP32, which is programmed using Embedded C/C++ language. Various sensors including humidity sensors, temperature sensors, airflow sensors, voltage sensors, and water level sensors are connected to the controller to continuously monitor environmental and system parameters. The software collects real-time data from these sensors and processes the information to control different hardware components automatically. Based on humidity and atmospheric conditions, the controller activates the fan or blower to intake air into the system and controls the electrostatic fog generation unit by regulating the high-voltage power supply. The software also manages the operation of the fog collection chamber and water purification unit to ensure efficient water harvesting and purification. Safety features are included in the program to prevent overvoltage, dry operation, and overflow conditions in the storage tank. In addition, the software displays important parameters such as humidity level, temperature, water quantity, and system status on an LCD display or IoT monitoring platform for real-time observation and performance analysis. Data logging and monitoring functions

help improve system efficiency, reliability, and automation for continuous water generation and air quality enhancement.

IX. RESULTS AND DISCUSSION

The proposed Integrated Electrostatic Fog Based Water Generation, Purification, and Air Quality Enhancement System was successfully designed and analyzed for efficient atmospheric water harvesting and environmental improvement. The system demonstrated the ability to collect moisture from humid air using electrostatic fog generation and condensation techniques. During operation, the fan or blower effectively directed atmospheric air into the electrostatic chamber, where charged fog particles were formed and attracted towards the collector plates for water collection. The collected water was then passed through the purification unit to improve water quality and remove impurities before storage. Experimental observations showed that the efficiency of water generation mainly depended on environmental conditions such as humidity, temperature, and airflow rate. Higher humidity levels resulted in increased fog formation and greater water collection efficiency. The electrostatic process improved the attraction and capture of microscopic water droplets, leading to better performance compared to conventional fog collection methods. In addition to water generation, the system also contributed to air quality enhancement by reducing dust particles and airborne impurities present in the incoming air.

The automatic control system successfully monitored sensor data and controlled system components such as the fan, high-voltage unit, and purification section with stable performance. Real-time monitoring through display and sensor feedback improved operational reliability and safety. The overall results indicate that the proposed system is an energy-efficient, eco-friendly, and sustainable solution for water scarcity problems, especially in regions with high atmospheric humidity and limited freshwater resources. The system can be further improved by integrating renewable energy sources, advanced filtration methods, and IoT-based monitoring for large-scale practical applications.

X. APPLICATIONS

- **Drinking Water Generation**

Used to generate clean water from atmospheric moisture in water-scarce regions.

- **Rural and Remote Areas**

Helpful in villages and remote locations where freshwater supply is limited.

- **Disaster Relief and Emergency Use**

Can provide portable water supply during floods, droughts, and natural disasters.

- **Air Quality Improvement**

Removes dust particles and airborne impurities while collecting atmospheric moisture.

- **Industrial and Commercial Use**

Can be used in industries, offices, and public buildings for sustainable water production.

- **Smart City and Green Building Applications**

Supports eco-friendly infrastructure and sustainable environmental management systems.

- **Agricultural Applications**

Useful for small-scale irrigation and greenhouse humidity management.

- **Renewable Energy Based Systems**

Can be integrated with solar or wind energy for energy-efficient operation.

XI. FUTURE SCOPE

- The proposed system can be improved by integrating solar energy and IoT-based monitoring for efficient operation.
- Advanced filtration and electrostatic technologies can increase water generation and purification efficiency.
- In future, the system can be widely used in smart cities, agriculture, and disaster management applications.

XII. CONCLUSION

The proposed Integrated Electrostatic Fog Based Water Generation, Purification, and Air Quality Enhancement System provides an innovative solution for generating water from atmospheric moisture. The system effectively utilizes electrostatic fog collection techniques to harvest water in an eco-friendly and sustainable manner. This approach helps reduce dependency on conventional water resources and supports environmental conservation.

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