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Solar Based Water Purifier

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Abstract - This project presents a solar-powered water purification system designed to deliver safe and affordable water using renewable energy. The system utilizes solar energy to power water filtration and includes sensors that continuously monitor key water quality parameters such as turbidity and total dissolved solids. A microcontroller processes this data and displays real-time values on an LCD screen while simultaneously uploading the readings to a cloud-based platform for remote monitoring. To make the system user-friendly and self-sustaining, a coin-operated module is integrated, which activates a water dispensing pump upon valid payment. The purified water is then delivered for a fixed duration, ensuring regulated access and reducing water waste. This innovative solution addresses environmental sustainability, energy efficiency, and ease of deployment, making it suitable for off-grid communities, public installations, and disaster-struck areas. The proposed system promotes decentralized water purification and supports broader efforts toward universal clean water access.

***Key Words*:** Solar energy, water purification, sustainable technology, IoT monitoring, automated dispensing, rural development, clean water access

1.INTRODUCTION

In many remote and underdeveloped regions, access to clean drinking water and reliable electricity remains limited. Solar-based purification systems provide an efficient and sustainable solution by utilizing renewable energy to operate without dependency on the power grid. This project, titled Solar Based Water Purifier, integrates solar energy with reverse osmosis (RO) technology to deliver safe and filtered drinking water [1].RO is widely adopted for its effectiveness in removing dissolved solids and microbial contaminants. While research has proposed intelligent control systems like fuzzy state-dependent Riccati equation (FSDRE) controllers for solar-powered RO plants [2], this project focuses on practical, low-cost implementation using standard components. The system continuously monitors Total Dissolved Solids (TDS) and turbidity levels using sensors. These values are displayed on an LCD and transmitted to the ThingSpeak cloud for real-time data logging [4]. An ESP32 microcontroller controls all operations, including water flow, data processing, and communication, leveraging its built-in Wi-Fi and low power consumption. User access is enabled through a coin-based vending mechanism that initiates water dispensing upon valid payment [3]. This compact, automated solution is well-suited for schools, communities, and rural areas facing water scarcity.

2. RELATED WORK

Research in the domain of water management and purification has evolved through diverse innovations. One approach [9] involved retrofitting conventional meters with intelligent components, enabling real-time usage tracking through cloud-connected deep learning, although scalability issues remain. Another study [10] incorporated renewable energy and edge computing to modernize analog meters, but broader deployment challenges persist. Efforts to improve water treatment efficiency through capacitive deionization [7] showed promise, though its effectiveness may vary with contaminant type. An integrated system [4] designed for simultaneous monitoring of water and energy utilized LPWAN for extended communication range, but practical adoption across varying infrastructure needs validation. Work conducted in remote regions [8] combined UV-based disinfection with solar energy and wireless tracking, although sustaining such setups in low-infrastructure areas remains difficult. A LoRa-based network [5] aimed at water quality assessment used machine learning for classification, yet the dependency on robust datasets limits reliability. Variable-frequency control integrated with solar-powered RO systems [6] contributed to performance enhancement, but system output remains sensitive to environmental conditions. Another method [2] merged fuzzy control logic with photovoltaic-driven desalination, offering improved automation, though still influenced by external climate factors. Experimental work on solar-powered purification designs [1] compared multiple configurations for effectiveness under different sunlight exposures. Lastly, a smart vending mechanism [3] implemented RFID for secure dispensing, yet raised concerns around operational consistency and hardware interference.

3. METHODOLOGY

3.1 Block diagram of the system:

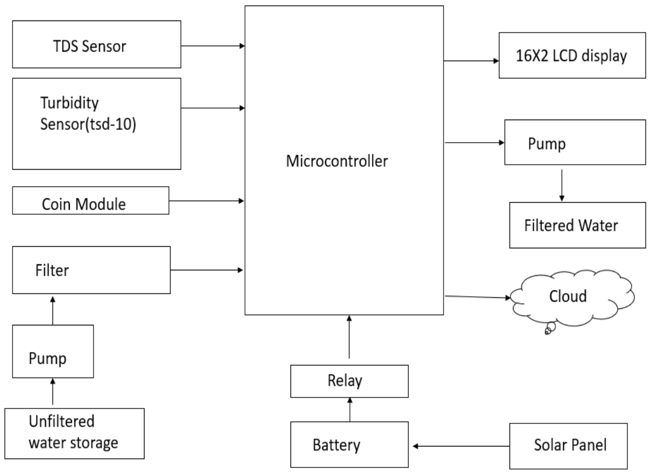

Fig. 1 Block diagram

The block diagram illustrates the overall architecture of a solar-powered water purification system integrated with smart monitoring and control capabilities. The system is centered around a microcontroller, which acts as the primary control unit interfacing with various input and output modules.

Input Components:

TDS Sensor: This sensor measures the Total Dissolved Solids (TDS) level in the water, providing an indication of water purity. It sends real-time data to the microcontroller.

Turbidity Sensor: This component detects the cloudiness or haziness in the water, which is caused by the presence of suspended particles. The turbidity reading helps determine the water quality.

Coin Module: The system includes a coin acceptor module, enabling a pay-per-use model for water dispensing. Upon insertion of a valid coin, the module sends a signal to the microcontroller to initiate water purification.

Unfiltered Water Pump and Filter: Water from the unfiltered storage is pumped through a filtration unit. The flow is controlled based on commands from the microcontroller.

Control Unit:

The microcontroller receives data from the TDS sensor, turbidity sensor, and coin module. Based on this data and user input, it manages the purification process and triggers appropriate actions, such as activating the water pump, displaying information, and updating cloud data.

Output Components:

16x2 LCD Display: Displays real-time information, including TDS and turbidity values, system status, and user prompts.

Pump: Controlled by the microcontroller to deliver filtered water after successful coin input and quality verification.

Cloud Integration: The system has cloud connectivity for storing and monitoring water quality data remotely, ensuring transparency and aiding maintenance decisions.

Power Management:

The entire system is powered by a battery, which is charged using a solar panel. The battery supplies power through a relay module, which is controlled by the microcontroller to ensure efficient power management. This off-grid capability makes the system highly suitable for remote or rural areas.

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3.2 Flowchart of the system:

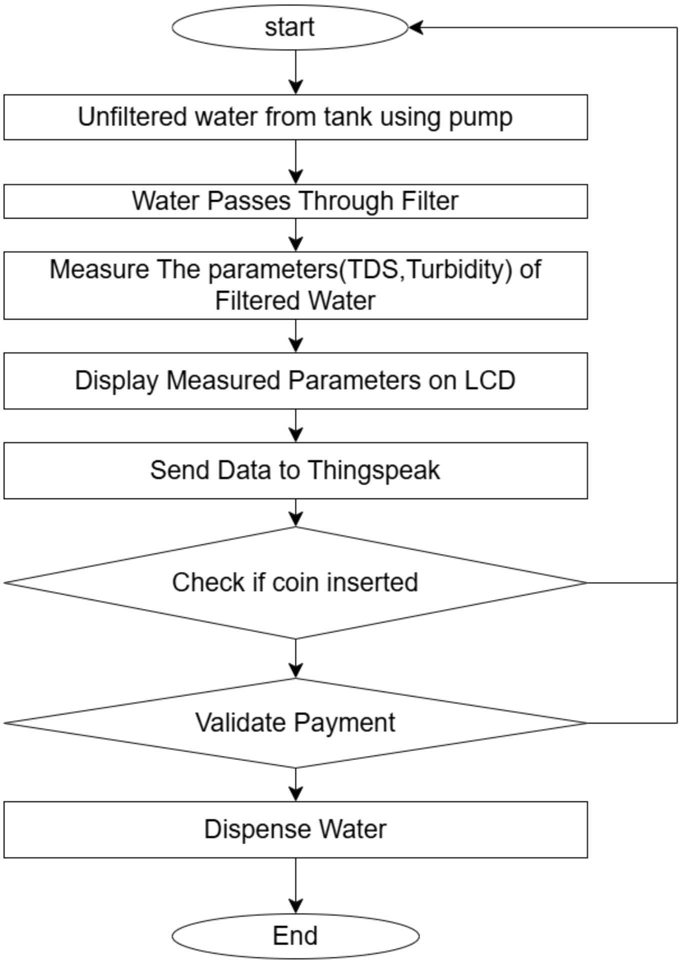

Fig. 2 Flowchart

1. The flowchart represents the working sequence of the solar-powered water purifier system. It begins with the intake of raw water from a storage tank, which is pumped into the filtration unit. This unit removes impurities and helps improve water quality.
2. After filtration, the system checks key water parameters such as Total Dissolved Solids (TDS) and turbidity using suitable sensors. These measured values are shown on an LCD display and also sent to the ThingSpeak platform for remote tracking.
3. Next, the system waits for a user to insert a coin. If no coin is inserted, the system stays in the idle state. Once a coin is detected, the system verifies the payment. If the payment is valid, the system proceeds to dispense the purified water.
4. This entire process is automated and designed for user convenience. It ensures that only clean water is provided and allows real-time monitoring of water quality, making the system suitable for community and rural applications.

3.3 Working of the System

The proposed solar-based water purification system begins by drawing contaminated water from a storage tank using a pump. This water is passed through a filter to remove suspended particles and visible impurities. Once filtered, the water quality is assessed using a TDS sensor and a turbidity sensor (TSD-10). These sensors measure the concentration of dissolved solids and the clarity of the water, respectively.

The measured values are displayed on a 16x2 LCD screen for user reference. At the same time, the data is sent to the ThingSpeak cloud platform for remote monitoring and future analysis. To proceed with dispensing, the system checks for coin insertion through a coin acceptor module. Upon successful payment validation, the ESP32 microcontroller activates a second pump that releases the purified water for user access.

The system is powered using a rechargeable battery that receives energy from a solar panel, promoting sustainable and continuous operation. A relay module is used to manage power flow and system switching. This setup ensures automated, energy-efficient, and real-time monitored water purification and dispensing.

4.RESULTS

Types of Water	TDS (before filtration) (ppm)	Turbidity (before filtration) (NTU)
Salty Water	1161	1.8
Sand water	35	3
RO water	0	0.1
Borewell water	35	1

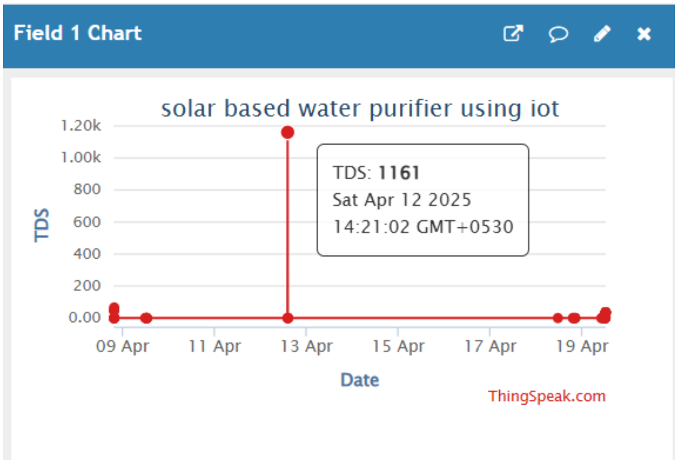

Fig.3 TDS value of salty water uploaded to ThingSpeak over time before filteration

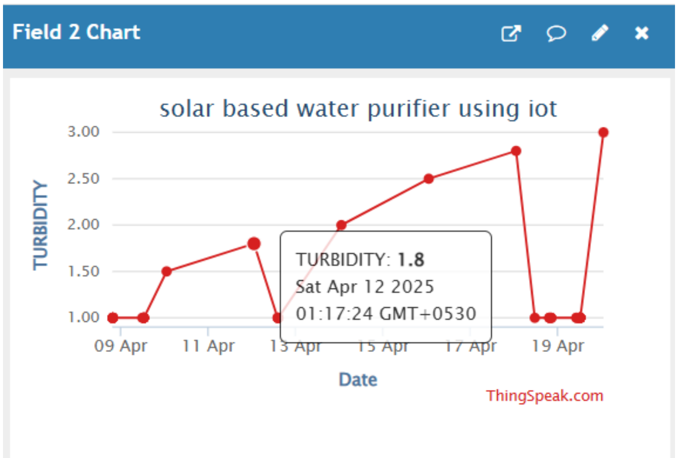

Fig.4 Turbidity value of salty water uploaded to ThingSpeak over time before filteration

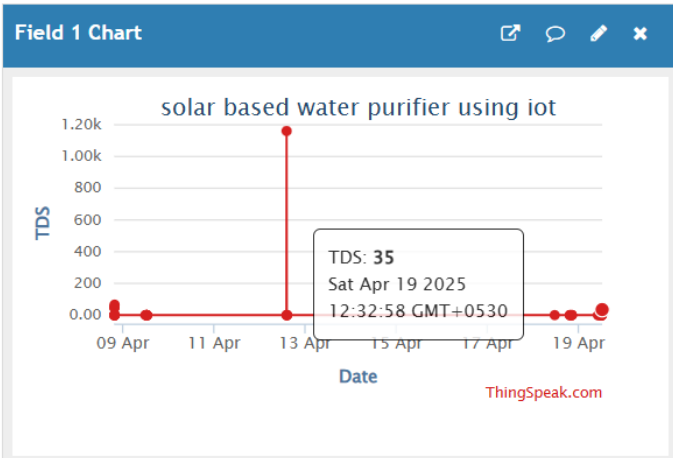

Fig.5 TDS value of sand water uploaded to ThingSpeak over time before filteration

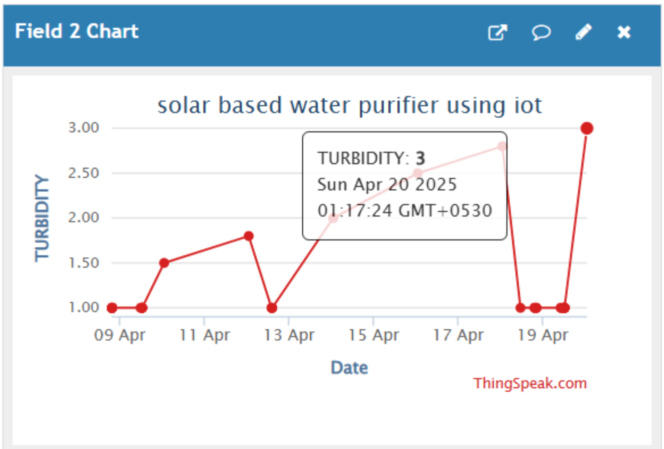

Fig.6 Turbidity value of sand water uploaded to ThingSpeak over time before filteration

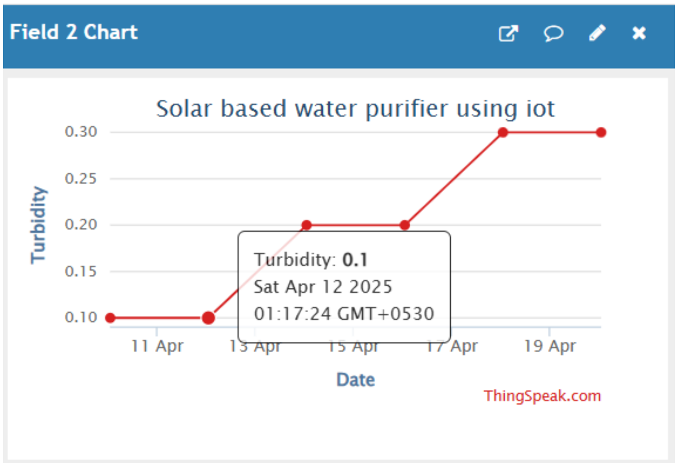

Fig.7 Turbidity value of RO water uploaded to ThingSpeak over time before filteration

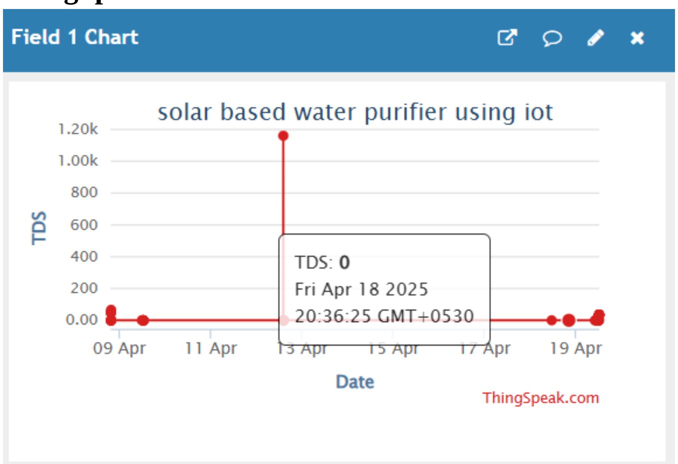

Fig.8 TDS value of RO water uploaded to ThingSpeak over time before filteration

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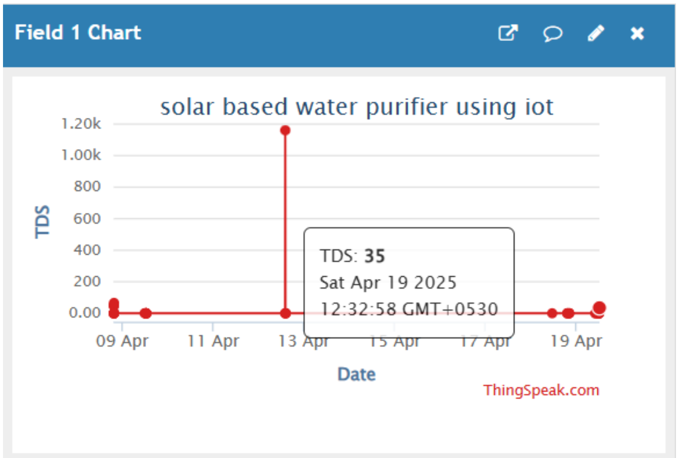

Fig.9 TDS value of Borewell water uploaded to ThingSpeak over time before filteration

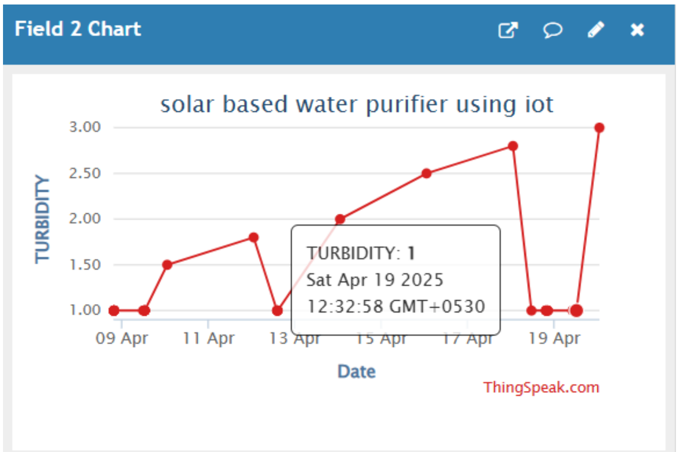

Fig.10 Turbidity value of Borewell water uploaded to ThingSpeak over time before filtration

Fig.11 Turbidity value displayed on LCD display

Fig.12 TDS values displayed on LCD

5. FUTURE SCOPE

1. **Advanced Water Quality Monitoring**
   Additional sensors can be integrated to detect parameters like conductivity, chlorine content, and microbial contamination for more comprehensive water analysis.

2. **Smart Payment and Authentication System**
   The existing coin system can be replaced with UPI or QR-based payments for a cashless experience. RFID or NFC can also be used to enable secure, user-specific access.

3. **IoT and Cloud Expansion**
   Data handling can be shifted from ThingSpeak to platforms like AWS, Google Cloud, or Firebase for better real-time monitoring. A mobile app could also be developed for users to track water quality, usage, and dispenser status, while enabling remote control for maintenance teams.

4. **Water Resource Management**
   The system can be expanded to purify water for irrigation, industrial processes, and wastewater treatment, supporting sustainable water use across various sectors.

6. CONCLUSION

This project successfully demonstrates a solar-powered water purification system integrated with IoT monitoring and a coin-based dispensing mechanism. The system significantly improved water quality, reducing Total Dissolved Solids (TDS) from 128 ppm to 6 ppm and maintaining low turbidity levels. Solar energy use ensured energy efficiency and sustainability, while the IoT platform allowed users to monitor water quality parameters remotely. The inclusion of a coin-based dispensing unit adds a practical access control feature, making it suitable for use in community-level installations. Overall, the system offers a reliable, low-maintenance, and scalable solution for providing clean drinking water in off-grid or resource-limited settings.

7.REFERENCES

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