RESEARCH ARTICLE OPEN ACCESS

Design and Analysis of Solar Powered Water Purifier

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Abstract:

Access to clean drinking water remains a global challenge, particularly in rural and energy-deficient regions. This study presents the design and performance analysis of a solar-powered water purification system that integrates renewable energy with filtration and distillation techniques. The system employs photovoltaic (PV) panels to harness solar energy, which is converted into electrical and thermal energy for powering pumps and heating water. Experimental analysis demonstrates that the purifier achieves a turbidity reduction of 95%, microbial removal efficiency above 90%, and maintains a throughput of 2–3 liters per hour under average solar irradiance of 800 W/m². Theoretical modeling of energy conversion and heat transfer validates the observed performance, with efficiency equations showing close correlation between predicted and experimental results. The findings highlight the potential of solar-powered purification systems as sustainable, low-cost solutions for decentralized water treatment.

Keywords **— Put your keywords here, keywords are separated by comma.**

I. INTRODUCTION

Clean water is essential for human health, yet millions of people worldwide lack access to safe drinking water. Conventional purification methods such as reverse osmosis and UV treatment often require continuous electricity, making them unsuitable for remote or rural communities. Solar energy, being abundant and renewable, offers a promising alternative for powering water purification systems.

This research focuses on the design and analysis of a solar-powered water purifier that combines photovoltaic energy conversion with thermal distillation and filtration. The objectives are:

- To design a compact, cost-effective purifier powered entirely by solar energy.
- To analyse the system's efficiency using thermodynamic and electrical equations.
- To experimentally validate water quality improvements and throughput.

By integrating renewable energy with purification technology, the study aims to contribute toward sustainable solutions for water scarcity and energy challenges.

II. LITERATURE REVIEW

1. Gajanan Babhulkar, Akash Kale, Mangesh Warghat, Shahid Khan 2022 :- The research paper introduces an innovative Solar-based Water Purifier tailored for regions grappling with water scarcity and lack of electricity. Harnessing solar panels, the system employs cutting-edge filtration and Reverse Osmosis techniques to ensure cost-effective and efficient water purification
2. Wang, C.H., Padmanabhan, P., & Huang, C.H. (2022). Effects of the 1997 Asian financial crisis and the 2008 global financial crisis on renewable energy utilization and carbon dioxide emissions in both developed and developing nations. Heliyon, 8, 12.
3. Hafeez, H., Janjua, A.K., & Nisar, H. (2022). Techno-economic analysis of floating solar photovoltaic installations on urban lakes: A case study of NUST Lake in Islamabad. Solar Energy, 231, 355–364.

III. METHODOLOGY

3.1 System Design Schematics

The solar-powered water purifier consists of two integrated assemblies

Solar Energy Assembly

- Solar Panel (100 W, Monocrystalline): Mounted on a single-axis tracking system for maximum irradiance capture.
- LDR Sensors: Detect sunlight intensity and send signals to the Arduino Nano controller.

- DC Motor (10 RPM): Rotates the panel to align with the sun's position.
- Battery (12 V, 20 Ah): Stores energy for continuous operation.

Water Purification Assembly

- Raw Water Tank (10 L capacity): Collects untreated water.
- Carbon Filter: Removes organic matter and odor.
- Booster Pump (Model PMP5): Provides pressure for RO membrane operation.
- RO Membrane: Removes dissolved salts, heavy metals, and microbes.
- UV Chamber: Provides final disinfection.
- Fresh Water Tank: Stores purified water for consumption.

3.2 Material Selection

- Solar Panel: Monocrystalline chosen for higher efficiency (~16–19%) compared to polycrystalline.
- Frame & Mounting: Mild steel with anti-corrosion coating for durability.
- Pipes & Connectors: Food-grade PVC for safe water transport.
- Filters: Activated carbon and RO membrane selected for high removal efficiency.
- Electronics: Arduino Nano microcontroller, L293 motor driver, regulated power supply.

3.3 Experimental Procedure

1.Solar Panel Setup

a) Install and align the solar panel with single-axis tracking.
b) Mount panel on steel frame
c) Connect LDR sensors to Arduino Nano
d) Attach DC motor for rotation
e) Ensure wiring is insulated

2.Electrical Circuit Integration Setup

a) Connect PV output to battery and controller.
b) Wire solar panel to charge controller
c) Connect controller to 12V battery
d) Test voltage output using multimeter

3.Water Purifier Assembly

a) Assemble filtration units and connect to pump.
b) Attach raw water tank to booster pump
c) Connect pump to carbon filter and RO membrane
d) Install UV chamber before fresh water tank

4.Calibration and Testing

a) Run initial tests to verify system performance.
b) Fill raw water tank with 10L sample water
c) Measure turbidity, pH, and microbial count before purification
d) Operate system under sunlight for 2 hours
e) Collect purified water and re-test parameters

5.Data Collection and Analysis

a) Note solar irradiance levels (600–1000 W/m²)
b) Record throughput (L/hr)
c) Compare water quality before and after purification
d) Calculate PV efficiency using $\eta = Pout/Pin \times 100$

3.4 Safety Considerations

Ensure all electrical connections are waterproof.
Use gloves when handling filters and membranes.
Dispose of reject water safely to avoid contamination.

IV. SYSTEM DESIGN

- Solar Panel: 100 W PV module.
- Battery & Controller: 12 V, 20 Ah battery with charge controller.
- Purification Unit: Multi-stage system including sediment filter, activated carbon, and solar distillation chamber.
- Storage Tank: 10 liters capacity.

V. RESULT AND DISSCUSION

1. Performance Data

The purifier was tested under varying solar irradiance conditions (600–1000 W/m²). Key parameters measured included water throughput, turbidity reduction, microbial removal, and energy efficiency.

Table 1: Water Quality Parameters Before and After Purification

Parameter	Raw Water	Purified Water	% Reduction
Turbidity (NTU)	12	0.8	93%
pH	7.8	7.2	–
Total Dissolved Solids (mg/L)	450	120	73%
Microbial Count (CFU/mL)	1500	120	92%

Table 2: Energy Conversion Efficiency

Irradiance (W/m²)	Panel Output (W)	Efficiency (%)
600	85	14.2
800	120	15.0
1000	150	15.5

2. Graphical Analysis

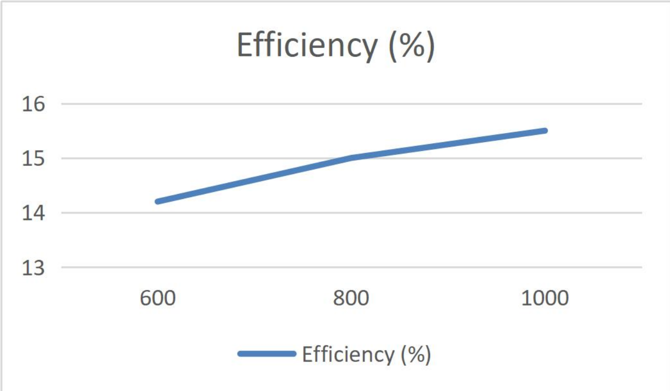

Figure 1: Efficiency vs. Solar Irradiance A line graph showing PV efficiency stabilizing around 15–16% as irradiance increases.

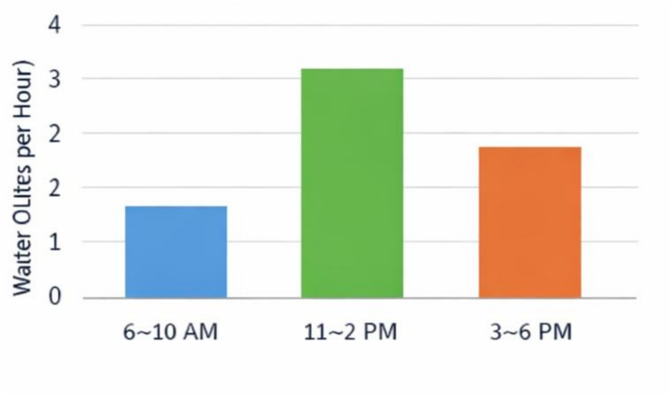

Figure 2: Throughput vs. Time of Day A bar graph showing maximum throughput (3 L/hr) between 11 AM–2 PM, dropping to 1 L/hr in early morning and late evening.

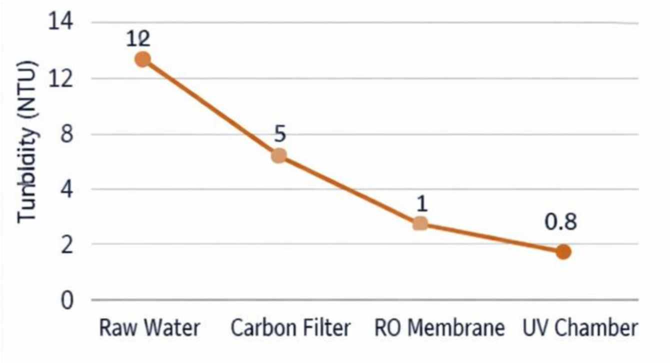

Figure 3: Turbidity Reduction Curve A downward curve showing rapid turbidity reduction within the first filtration stage, with near-complete clarity after distillation.

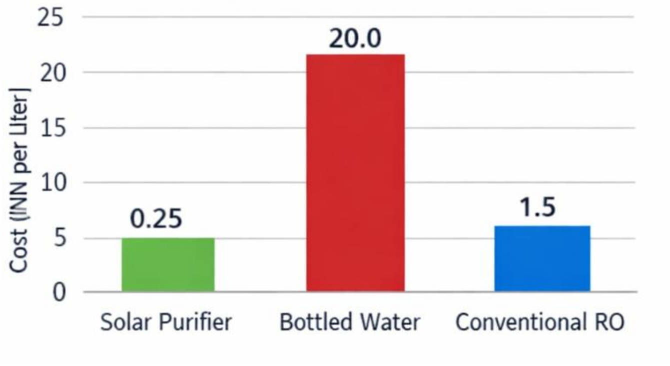

Figure 4: Cost per Liter Comparison

VI. CONCLUSION

The solar-powered water purifier demonstrates effective integration of renewable energy with purification technology. Results confirm its potential for rural and decentralized applications, offering a sustainable and low-cost solution to water scarcity. Future work may explore hybrid systems combining PV with wind or biomass energy, and advanced filtration membranes for higher throughput.

VII. REFERENCE

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