International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 10 | Oct - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Review On Solar-Powered Water Purification System: A Sustainable Solution for Clean Drinking Water

Saniya Akbarkhan Pathan[1], Ashita Sunil Sadakale[2], Mohammad Jaid Altaf Desai[3], Aarman Iqbal Shaikh[4], Shripad Balasaheb Jadhav[5], Nitin Nandkumar Bhore[6]

[1,2,3,4] Students, Department of Mechanical Engineering, Sanjay Bhokare Group of Institutes Miraj, Maharashtra, India

[5] Workshop Superintendent, Department of Mechanical Engineering, Sanjay Bhokare Group of Institutes Miraj, Maharashtra, India

[6] Lecturer, Department of Mechanical Engineering, Sanjay Bhokare Group of Institutes Miraj, Maharashtra, India

Abstract Access to safe drinking water remains a challenge in rural and remote locations where grid electricity is unreliable and conventional water treatment equipment may be difficult to operate continuously. This survey paper reviews the literature and technical approach described in the project synopsis for a small-scale solar-powered water purification system. The proposed arrangement combines a photovoltaic (PV) panel, charge controller, optional battery, DC water pump, sediment filtration, activated-carbon filtration, fine filtration and ultraviolet (UV) disinfection. The reviewed studies indicate that solar energy can support decentralized water treatment and reduce dependence on conventional electricity. The synopsis also identifies practical engineering considerations, including pump head, flow rate, solar- panel sizing, energy storage, filter pressure loss and water-quality testing. The proposed prototype is intended for educational and small-scale evaluation, with an initial target of 20 litres per day. No performance results are claimed in this paper because testing is planned as part of the project. The paper concludes that solar-powered purification is a promising approach, provided that the system is correctly sized, maintained and validated through suitable water- quality and microbiological tests.

Keywords: Solar photovoltaic energy, water purification, renewable energy, DC pump, multi-stage filtration, UV disinfection, sustainable engineering.

1. Introduction

Water from wells, borewells, rivers and ponds can contain suspended particles, dissolved substances, organic matter and microorganisms. Industrial discharge, agricultural chemicals, domestic waste and natural impurities can affect water quality. Conventional small-scale purification systems may use pumps, membranes or UV lamps that require electricity. Where supply is irregular, treatment may be interrupted.

Solar photovoltaic technology converts sunlight directly into electrical energy and can therefore support water treatment at locations with limited grid access. The project considered in this survey combines a solar power section with a water purification section. Its intended applications include rural households, schools, farms, remote institutions and temporary relief locations. The project also provides a practical application of mechanical design, fluid mechanics, renewable energy and fabrication.

The purpose of this paper is to summarize the literature cited in the synopsis, compare the approaches at a qualitative level, identify engineering issues that need attention and describe the proposed system and its planned evaluation.

2. Scope and Method of Survey

This survey is based on the four publications listed in the supplied project synopsis: work on hybrid solar-powered purification, a sustainable solar-powered purification system, solar-assisted membrane technology, and photovoltaic-powered UV/visible-light disinfection. The synopsis provides short summaries rather than complete experimental datasets. Accordingly, this paper reports the themes and conclusions described in those summaries and does not infer unreported numerical performance, removal efficiencies or cost comparisons.

3. Review of Literature

3.1 Hybrid PV, Ultrafiltration and UV Treatment Bhattacharya and Sarkar (2026) are described in the synopsis as studying a hybrid solar-powered water purification and energy system for rural and semi-urban households. Their approach integrates solar photovoltaic energy with ultrafiltration and UV technologies and is intended for locations with unreliable electricity. The synopsis notes that the system also considered services such as lighting and USB charging. This work highlights the potential of combining renewable electricity and decentralized water treatment in one system [1].

3.2 Sustainable Solar-Powered Purification Paul et al. (2025) presented a solar-powered water purification system using photovoltaic panels to generate electricity for treatment. According to the synopsis, the study emphasized reducing reliance on conventional power and discussed the environmental and economic relevance of solar-powered purification in rural and off-grid areas.
The study supports the general concept of using solar PV as an energy source for small-scale water treatment [2].

3.3 Solar-Assisted Membrane Technologies Zewdie et al. (2021) reviewed solar-assisted membrane technologies for water purification. The synopsis indicates that their review examined renewable-energy integration with membrane processes, potential reductions in electricity consumption and the role of membranes in contaminant removal. It also identified technical challenges and the need to improve efficiency and sustainability. This literature is relevant when considering membrane filtration as an optional treatment stage, depending on the source-water characteristics and required output quality [3].

3.4 PV-Powered UV and Visible-Light Disinfection Lui et al. (2014) investigated photovoltaic-powered ultraviolet and visible-light-emitting diode technologies for drinking-water disinfection. As summarized in the synopsis, their work considered point-of-use treatment and the potential of light-based technologies to reduce microbial contamination. It provides relevant background for operating a disinfection stage from solar-generated electricity in decentralized systems [4].

4. Comparative Summary of the Reviewed Literature

Study Main technology or focus Relevance to the project Consideration noted in synopsis Bhattacharya & Sarkar (2026)

[1]

PV with ultrafiltration and UV;

hybrid system Supports integrated, decentralized treatment powered by solar energy Designed for unreliable electricity; additional energy services considered Paul et al. (2025) [2] PV-powered water purification Supports the general design concept and off-grid application Emphasizes reduced dependence on conventional power Zewdie et al. (2021) [3] Review of solar-assisted membrane processes Provides context for optional membrane treatment Efficiency and practical technical challenges require attention Lui et al. (2014) [4] PV-powered UV/visible-light disinfection Supports solar-powered disinfection at point of use Disinfection performance must be appropriate to operating conditions

5. Research Gap and Need for the Proposed System

The synopsis identifies a practical need for a compact purification system that does not depend fully on grid electricity. Existing approaches discussed in the reviewed literature demonstrate relevant technologies, but the project still needs to establish how the selected components perform together under local operating conditions. The main points requiring evaluation are:

- Reliable operation under changing solar irradiance and periods of limited sunlight.
- Selection of a pump that delivers the required flow at the actual total dynamic head, including pipe, fitting and filter losses.

- Correct matching of PV output, controller, optional battery, pump and UV-unit energy demand.
- Measurement of water-quality changes before and after treatment, rather than assuming that filtration alone makes water potable.
- Verification of UV operating conditions and microbial safety through suitable testing before making any claim that the water is safe to drink.
- Documentation of daily treated-water volume, maintenance needs, component cost and limitations of the prototype.

These points are framed as evaluation needs arising from the supplied synopsis; they are not presented as measured deficiencies of the four cited studies.

6. Proposed Solar-Powered Water Purification System

6.1 System Components The proposed prototype consists of two connected sections. The solar power section includes a 75 W, 12 V polycrystalline PV panel, a 12 V/10 A PWM charge controller, an optional 12 V/20 Ah lead-acid battery, wiring, protection and switches. The water-treatment section includes a raw-water tank, a 12 V DC pump rated in the synopsis at 10 L/min and 10 m head, a 10-inch sediment filter, a 10-inch activated-carbon filter, a 5-micron fine filter, a 12 V DC/6 W UV unit, pipes and valves, and a separate treated-water tank. These are preliminary component specifications from the synopsis and must be checked against actual operating requirements.

6.2 Working Principle The PV panel converts sunlight into DC electricity. A charge controller regulates the electrical supply and manages battery charging if a battery is used. The electrical system supplies the DC pump and UV unit. The pump moves raw water through the treatment stages in sequence. The sediment filter is intended to remove sand, dust and rust;
activated carbon can reduce odour, colour and some organic compounds; the fine filter retains smaller particles; and the UV stage is intended to inactivate microorganisms when operated at a suitable flow and dose. Treated water is collected in a separate tank.

Water path: Raw-water tank → DC pump → Sediment filter → Activated-carbon filter → Fine filter → UV unit → Treated-water tank

6.3 Design and Engineering Considerations The synopsis proposes calculating total dynamic head as the sum of static head and losses through pipes, fittings and filters. Hydraulic power can be estimated using $P_h = \rho g Q H$, where ρ is water density, g is gravitational acceleration, Q is flow rate and H is total head. Electrical pump input must then be estimated using suitable efficiency data and manufacturer specifications. Daily energy demand should include the pump, UV unit and controller. PV sizing should account for effective sunshine hours and derating factors; battery sizing, if used, should account for energy demand, system voltage, permissible depth of discharge and efficiency.
Mechanical design tasks include preparing CAD drawings, selecting frame materials, checking tank loads and stability, routing pipes, mounting the panel at an appropriate tilt for Miraj, fabricating the frame and assembling the system. Pressure ratings, flow limits and electrical compatibility must be checked before operation.

7. Proposed Methodology and Performance Evaluation

1. Define the source-water type, prototype target volume and treatment requirements. The synopsis gives an initial
target of 20 L/day for prototype testing.

2. Prepare CAD layouts, frame drawings, pipe routing and mounting arrangements.

3. Complete calculations for daily water requirement, pump head, flow rate, PV capacity and optional battery capacity.

4. Select components by checking the pump curve at the expected head, filter-housing pressure ratings and the UV
unit's rated flow and dose requirements.

5. Fabricate the frame and securely mount the tanks, PV panel and treatment components.

6. Assemble the water line in the specified sequence and connect the PV, controller, fuse, switch, battery if used, pump and UV unit with suitable electrical protection.

7. Check for leakage and electrical safety before performance testing.

8. Measure PV voltage and current, pump discharge and head, operating duration, energy use, daily treated-water
volume, pH, TDS and turbidity before and after treatment.

9. Arrange appropriate microbiological testing if the project intends to claim that the treated water is potable; compare results with applicable water-quality requirements.

10. Record cost, maintenance requirements, limitations and any design revisions.

8. Expected Benefits and Feasibility

The expected benefits stated in the synopsis include reduced dependence on grid electricity, use of renewable energy during operation, potential reduction in operating electricity costs, and suitability for decentralized use. A compact prototype may also be portable and modular, allowing treatment stages to be selected according to source-water needs. The project has educational value because it combines mechanical fabrication, fluid mechanics, pumping, solar energy and water treatment.

The synopsis estimates a prototype cost of approximately ₹15,000–₹25,000 and periodic filter replacement costs of ₹500–₹800 every three to six months. These are estimates from the project plan, not verified quotations or measured lifecycle costs. Technical feasibility depends on correct sizing and component compatibility. Economic feasibility depends on actual use, maintenance and local alternatives. Environmental benefits are associated with solar operation, while batteries and used filters require responsible handling and disposal.

9. Limitations and Safety Considerations

The system's performance will vary with solar irradiance, shading, pump head, filter pressure loss, source-water quality and UV operating conditions. Activated carbon and particulate filters do not remove every possible dissolved contaminant, and a reduction in TDS cannot be assumed for the proposed filter train. UV disinfection is dependent on suitable dose, flow and water clarity. Therefore, the prototype must not be described as producing safe drinking water solely because the water passes through the listed stages. Water-quality testing, including microbiological testing

where potability is claimed, is necessary. Regular tank cleaning, filter replacement, leak checks, electrical protection and appropriate battery disposal are also important.

10. Conclusion

The literature summarized in the supplied synopsis supports the potential of combining solar photovoltaic energy with decentralized water treatment. The proposed system uses a PV-powered DC pump and a multi-stage treatment train comprising sediment, activated-carbon and fine filtration followed by UV disinfection. Its intended purpose is to provide an educational, small-scale option for locations where grid electricity is unreliable. The final performance cannot be established from the literature review alone; it must be determined experimentally by measuring flow, energy use and water quality under different solar conditions. Correct component sizing, routine maintenance and appropriate microbiological validation are essential before the system can be recommended for drinking-water use.

References

[1] Bhattacharya, S., & Sarkar, P. (2026). Design and evaluation of a hybrid solar-powered water purification and energy system for rural and semi-urban households. Energy for Sustainable Development, 91, 101917.

https://doi.org/10.1016/j.esd.2025.101917

[2] Paul, D., Babu, R. M., Hossain, M. K., & Uddin, M. J. (2025). Design and implementation of a sustainable solar-powered water purification system for safe drinking water. 2025 IEEE International Conference on Environment and Electrical Engineering and IEEE Industrial and Commercial Power Systems Europe.

https://doi.org/10.1109/EEEIC/ICPSEurope64998.2025.11169053

[3] Zewdie, T. M., Habtu, N. G., Dutta, A., & Van der Bruggen, B. (2021). Solar-assisted membrane technology for water purification: A review. Water Reuse, 11(1), 1–32. https://doi.org/10.2166/wrd.2020.049

[4] Lui, G. Y., Roser, D., Corkish, R., Ashbolt, N., Jagals, P., & Stuetz, R. (2014). Photovoltaic powered ultraviolet and visible light-emitting diodes for sustainable point-of-use disinfection of drinking waters. Science of the Total Environment, 493, 185–196. https://doi.org/10.1016/j.scitotenv.2014.05.104