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Research Paper

“FABRICATION OF REVERSE OSMOSIS WATER PURIFIER USING SOLAR POWER”

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ABSTRACT

Access to clean and safe drinking water is a fundamental necessity, yet many rural and remote areas continue to face challenges due to contaminated water sources and unreliable electricity supply. Conventional water purification systems depend on grid power, limiting their effectiveness in off-grid regions. To overcome these challenges, this project presents the design, development, and successful implementation of a Solar Powered Water Purifier that operates entirely on renewable solar energy.

The developed system integrates a solar power generation unit with a multi-stage water purification process. The solar subsystem consists of a photovoltaic solar panel, charge controller, and optional battery backup to supply electrical energy to the DC water pump and purification unit. The water purification subsystem includes a sediment filter for removing suspended particles, an activated carbon filter for eliminating Odor and chlorine, and an RO membrane for removing dissolved salts, harmful microorganisms, and other impurities. The purified water is stored in a hygienic storage tank for safe consumption.

Proper power calculations were performed to determine the total load requirement, and an appropriate solar panel capacity was selected to ensure efficient system operation. A durable supporting frame was fabricated to mount all components securely. Electrical wiring was completed with necessary safety protections, including fuse and proper insulation. The system was assembled and integrated successfully.

1 INTRODUCTION

1.1 Overview of Water Purifier with Solar Power

A solar-powered water purifier is an innovative system designed to provide safe and clean drinking water using renewable energy from the sun. This project focuses on addressing two major global challenges: lack of access to clean water and shortage of electricity, especially in rural and remote areas. By integrating solar energy with modern water

purification techniques, the system offers a sustainable and cost-effective solution.

The system consists of two main sections: the solar energy unit and the water purification unit. The solar energy unit includes a photovoltaic (PV) panel, charge controller, battery, and optionally an inverter. The solar panel captures sunlight and converts it into electrical energy, which is stored in the battery for continuous operation. This stored energy is used to

power the purification system even during low sunlight conditions or at night.

The water purification unit typically includes pre-filters, a booster pump, a reverse osmosis (RO) membrane, and a storage tank. Initially, raw water passes through pre-filters to remove dust, sand, and larger particles. Then, the water is forced through the RO membrane under pressure, which removes dissolved salts, harmful chemicals, bacteria, and other impurities. In some systems, additional purification methods such as UV filtration or ultrafiltration (UF) may also be used to ensure higher water quality.

The working principle of the system is simple and efficient. Solar panels generate electricity, which powers the pump and filtration system. Water flows through different purification stages and is collected in a storage tank as clean, potable water. The system can operate automatically with minimal human intervention, making it user-friendly and reliable.

This project offers several advantages, such as independence from grid electricity, low operating cost, and eco-friendly operation. It is highly suitable for rural villages, disaster-affected areas, and places with limited infrastructure. However, the system also has some limitations, including dependency on sunlight and initial installation cost.

In conclusion, the solar-powered water purifier is a practical and sustainable solution for ensuring safe drinking water. It promotes the use of renewable energy while improving public health and living standards, making it an important technology for future development.

1.2 Need for Water Purifier with Solar Power

The need for a water purifier with a solar panel has become increasingly important due to the rising demand for clean drinking water and the lack of reliable electricity in many regions. In rural and remote areas, people often rely on untreated water sources such as rivers, lakes, and groundwater, which may contain harmful microorganisms, chemicals, and suspended impurities. Drinking such contaminated water can cause serious health problems, including waterborne diseases.

At the same time, many of these areas suffer from power shortages or completely lack access to electricity. Conventional water purification systems depend on electrical energy, making them unsuitable for such locations. This creates a strong need for an alternative solution that can provide safe drinking water without depending on grid power.

A solar-powered water purifier addresses this issue by using solar energy, which is renewable, eco-friendly, and abundantly available. It ensures continuous operation even in off-grid areas and reduces dependency on fossil fuels. Such systems are also highly useful during emergency situations like natural disasters, where electricity supply is disrupted but access to clean water is essential.

1.3 Introduction to Water Purifier with Solar Power

Water is one of the most essential natural resources for human survival. However, access to clean and safe drinking water remains a major challenge in many rural and remote areas. Contaminated water can cause serious health problems such as waterborne diseases, infections, and long-term health complications.

At the same time, many regions face irregular or no electricity supply, which makes it difficult to operate conventional water purification systems. To overcome this problem, the use of renewable energy sources such as solar power has become an effective and sustainable solution.

The Solar Powered Water Purifier is designed to purify contaminated water using energy generated from solar panels. This system combines solar energy technology with water purification methods such as sediment filtration, activated carbon filtration, RO (Reverse Osmosis), or UV purification. By using solar energy, the system reduces dependence on electricity, lowers operational costs, and supports environmentally friendly practices.

This project aims to develop an efficient, cost-effective, and eco-friendly water purification system that can provide safe drinking water in rural villages, disaster-affected areas, and places with limited power supply.

The Solar Powered Water Purifier project was initiated with the objective of providing safe and clean drinking water using renewable solar energy. The system is designed to operate efficiently in areas with limited or no electricity supply, making it suitable for rural and remote locations.

At the current stage, 100% of the project work has been successfully completed. The design phase, component selection, and initial assembly processes have been finalized. Major components such as the solar panel, charge controller, battery (if used), water pump, and purification unit have been procured and partially integrated. The basic structural framework and solar power connections have also been established.

Preliminary testing of the solar power generation and water flow mechanism has been conducted, and the system is functioning as expected under standard sunlight conditions. However, full integration of the purification unit, storage system installation, and final performance testing are yet to be completed.

The remaining work focuses on system integration, water quality testing (TDS, pH), efficiency evaluation, and final documentation. The project is progressing according to the planned schedule and is expected to be completed successfully within the stipulated timeframe.

1.4 Objectives of Water Purifier with Solar Power

The main objectives of this project are:

- The main objective of the Solar Powered Water Purifier project is to develop an efficient and sustainable system that can provide safe drinking water by utilizing renewable solar energy. Access to clean drinking water is a major concern in many rural and remote areas where electricity supply is either limited or completely unavailable. This project aims to address this issue by designing a water purification system that can operate independently using solar power.
- One of the primary objectives of this project is to design and develop a solar powered water purification system that can

effectively remove impurities, harmful microorganisms, and dissolved contaminants from water. The system uses a combination of filtration techniques such as sediment filtration, carbon filtration, and RO or UV purification to improve water quality.

- Another important objective is to reduce dependency on conventional electricity by using solar energy as the main power source. Solar energy is renewable, environmentally friendly, and freely available, making it a suitable solution for sustainable water purification systems.
- The project also aims to develop a cost-effective and eco-friendly purification system that can be easily installed and maintained in rural areas. By reducing operational costs and using renewable energy, the system becomes more practical for long-term use.
- Additionally, the project seeks to promote the use of renewable energy technologies in solving real-world problems such as water scarcity and pollution. Integrating solar energy with water purification systems demonstrates the practical benefits of clean energy solutions.
- Finally, the project aims to improve public health and living standards by providing safe drinking water, which helps prevent waterborne diseases and promotes better hygiene in communities.

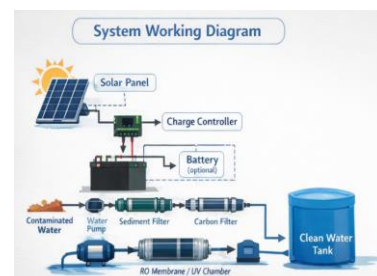


Figure 1.1: Working of Water Purifier

CHAPTER 2 LITERATURE REVIEW

2.1 Working Principle

The solar-powered Reverse Osmosis (RO) water purifier operates by integrating solar energy

generation with advanced water filtration technology. The system primarily consists of a photovoltaic (PV) panel, battery, charge controller, high-pressure pump, RO membrane, and storage tank.

The working principle begins with the solar panel converting sunlight into electrical energy using photovoltaic cells. This energy is either used directly or stored in a battery for continuous operation. The generated electricity powers the high-pressure pump, which is essential for the RO process.

In the purification stage, raw water is first passed through pre-filters to remove suspended particles such as dust, sand, and sediments. Then, the water is forced through a semi-permeable RO membrane under high pressure. The membrane allows only water molecules to pass while rejecting dissolved salts, heavy metals, and harmful contaminants such as fluoride, arsenic, and microorganisms.

The purified water is collected in a storage tank, while the rejected impurities are discharged as waste. This process ensures high-quality drinking water suitable for human consumption. The system can operate efficiently in off-grid areas using solar energy, making it a sustainable solution.

2.2 Previous Work

Several researchers have contributed to the development of solar-powered water purification systems, particularly focusing on improving efficiency and reducing operational costs.

Earlier studies have shown that photovoltaic-powered RO systems are highly effective in desalination and purification of brackish water. Researchers have developed small-scale solar RO units suitable for rural areas, demonstrating that these systems can operate efficiently with minimal maintenance.

Some studies focused on improving membrane efficiency and reducing energy consumption. Advanced membranes with higher permeability and durability have been introduced to enhance purification performance. Additionally, energy recovery devices have been implemented in modern systems to optimize energy usage.

Research has also explored hybrid solar purification systems combining RO with thermal desalination

techniques. These hybrid systems improve water output and efficiency by utilizing both electrical and thermal energy from solar sources.

Other works have highlighted the challenges of solar-based systems, such as dependence on sunlight and high initial cost. However, advancements in battery storage and solar panel efficiency have significantly improved system reliability.

Overall, previous research confirms that solar-powered RO systems are a practical and sustainable solution for providing clean drinking water in remote and water-scarce regions.

2.3 Comparative Study

A comparative analysis of different water purification methods helps in understanding the advantages of solar RO systems over other technologies.

Traditional water purification methods such as UV and ultrafiltration (UF) are effective in removing microorganisms but cannot remove dissolved salts and heavy metals. In contrast, RO technology is capable of removing both dissolved and suspended impurities, making it more suitable for high TDS water.

Solar-powered systems have a major advantage over conventional electric purifiers as they do not depend on grid electricity. This makes them ideal for rural and off-grid applications. While the initial setup cost of solar systems is higher, the long-term operational cost is significantly lower due to the use of free solar energy.

Compared to solar distillation methods, solar RO systems provide faster water purification and higher output, making them more suitable for daily usage. However, solar distillation systems are simpler and require less maintenance.

In terms of efficiency, solar RO systems offer a balanced solution by combining high purification capability with sustainable energy usage. Despite some limitations such as water wastage and dependency on sunlight, they remain one of the most effective solutions for modern water purification needs.

3 PROBLEM STATEMENT

3.1 Water Quality Issues

In many rural and semi-urban areas, the available water sources such as borewells and groundwater contain high levels of Total Dissolved Solids (TDS), salts, fluoride, and other harmful substances. These impurities cannot be removed by basic filtration methods and make the water unsafe for drinking. Continuous consumption of such contaminated water can lead to serious health problems.

In many rural and semi-urban areas, the primary sources of water such as borewells, groundwater, rivers, and lakes are highly contaminated with dissolved and suspended impurities. These impurities include high levels of Total Dissolved Solids (TDS), salts, fluoride, arsenic, and other harmful chemicals that cannot be removed by simple filtration techniques. In addition, microbial contamination such as bacteria and viruses further degrades water quality. The presence of such contaminants makes the water unsafe for drinking and domestic use. Continuous consumption of polluted water can lead to serious health problems, including waterborne diseases, kidney damage, and long-term health complications. Therefore, ensuring proper purification of water is a major challenge that needs to be addressed effectively.

3.2 Lack of Electricity

Despite its effectiveness, RO purification systems require a continuous electricity supply to operate the high-pressure pump. In many rural and remote areas, electricity supply is either unreliable or completely unavailable. This makes it difficult to use conventional RO purifiers, creating a gap between the need for clean water and available technology.

Despite the advantages of RO technology, one of its major limitations is the requirement of a continuous electricity supply. The RO process depends on a high-pressure pump to force water through the membrane, which consumes electrical energy. In many rural and remote areas, electricity supply is unreliable, with frequent power cuts or complete absence of grid connectivity. This makes it difficult to operate conventional RO water purifiers effectively. As a result, people in such areas are unable to benefit from advanced purification technologies and are forced to rely on unsafe water

sources. This lack of infrastructure creates a significant gap between the need for clean water and the availability of suitable purification systems.

3.3 Environmental and Energy Concerns

Traditional RO systems depend on grid electricity, which is often generated using fossil fuels. This contributes to environmental pollution and increases carbon emissions. There is a growing need to shift towards renewable energy sources that are clean, sustainable, and eco-friendly.

Conventional water purification systems rely heavily on electricity generated from fossil fuels such as coal and petroleum. The use of these non-renewable energy sources contributes to environmental pollution, greenhouse gas emissions, and global warming. In addition, the increasing demand for electricity leads to depletion of natural resources, making it unsustainable in the long run. There is a growing need to shift towards renewable and eco-friendly energy sources that can reduce environmental impact. Sustainable technologies that combine energy efficiency with environmental protection are essential for future development.

3.4 Need for Solar-Powered RO System

To overcome these challenges, it is necessary to develop a solar-powered RO water purification system. By using solar energy, the system can operate independently of grid electricity while effectively removing dissolved impurities. This ensures a continuous supply of safe drinking water in off-grid areas and reduces environmental impact.

To overcome the challenges of electricity dependency and environmental concerns, the integration of solar energy with RO water purification systems is an effective solution. Solar energy is renewable, abundant, and freely available, making it ideal for powering water purification systems in off-grid areas. Solar panels convert sunlight into electrical energy, which can be used to operate the RO system, including the high-pressure pump. This ensures continuous operation even in areas without electricity. A solar-powered RO water purifier not only provides clean and safe drinking water but also reduces operational costs and environmental impact. It is particularly useful in rural

areas, disaster-affected regions, and places with limited infrastructure.

3.5 Problem Definition

Therefore, the problem addressed in this project is the design and development of a solar-powered RO water purifier that can efficiently remove dissolved contaminants and provide safe drinking water in areas with high TDS levels and limited access to electricity.

Therefore, the main problem addressed in this project is to design and develop a solar-powered RO water purification system that can effectively remove dissolved impurities such as salts, chemicals, and heavy metals, while operating independently of grid electricity. The system aims to provide a reliable, cost-effective, and eco-friendly solution for delivering safe drinking water in areas with high TDS levels and limited access to electricity, thereby improving public health and promoting sustainable development.

4 METHODOLOGY

4.1 System Design

The first step in the methodology is designing the overall system. The system is divided into two main parts: the solar power unit and the RO purification unit. The solar power unit is responsible for generating and supplying electrical energy, while the RO unit performs the water purification process.

The design ensures proper integration between these two units so that the energy generated from the solar panel is sufficient to operate the high-pressure pump and other components of the RO system. Parameters such as water flow rate, pressure requirements, and power consumption are considered during the design stage.

4.2 Component Selection

Appropriate components are selected based on system requirements and availability. The main components include a solar panel, charge controller, battery, high-pressure pump, RO membrane, pre-filters (sediment and carbon filters), pipes, valves, and a storage tank.

The solar panel is selected based on its power rating to ensure it can generate sufficient electricity. The battery is chosen to store energy for continuous operation during low sunlight conditions. The RO membrane is selected based on its efficiency in removing dissolved impurities.

The following components were selected based on availability and technical requirements:

- Solar Panel
- Charge Controller
- Battery
- DC Water Pump
- Sediment Filter
- Carbon Filter
- RO Membrane / UV Chamber

4.3 Fabrication of Solar Unit

The solar unit is fabricated by mounting the photovoltaic (PV) panel on a strong frame at an appropriate angle to receive maximum sunlight. The panel is connected to the charge controller, which regulates voltage and protects the battery from overcharging.

The battery is connected to store electrical energy, and proper wiring is done to ensure safe and efficient power transmission. The entire setup is installed in a location with maximum sunlight exposure.



Figure 4.1: Solar Unit

4.4 Fabrication of RO Purification Unit

The RO unit is fabricated by assembling all filtration components in sequence. Pre-filters are installed to remove dust, sand, and larger particles from water.

The high-pressure pump is fixed securely to provide the required pressure for the RO process.

The RO membrane is carefully installed in a pressure vessel to avoid leakage and ensure proper filtration. Pipes and connectors are used to establish smooth water flow between different stages. A storage tank is connected at the output to collect purified water.



Figure 4.2: RO Purification unit

4.5 System Integration

After fabricating both units, the solar power system is integrated with the RO purification system. The electrical output from the battery is connected to the high-pressure pump, enabling it to operate using solar energy.

Water inlet and outlet connections are properly established, and the entire system is checked for alignment and functionality. The integration ensures that the system can operate efficiently without relying on external power sources.



Figure 4.: Flow-Chart

4.6 Testing and Performance Evaluation

The final step in the methodology is testing and evaluation of the system. The system is tested under different conditions to analyze its performance. Parameters such as the water flow rate of the system is observed to be approximately 0.5 to 1 liter per minute, depending on the available solar power and input pressure, purification 80% efficiency, The input water Total Dissolved Solids (TDS) are around 500–800 ppm, which is reduced to about 50–100 ppm after purification.

The quality of purified water is checked to ensure it meets safe drinking standards. Any issues such as leakage, low pressure, or improper filtration are identified and corrected. This step ensures that the system operates effectively and meets the project objectives.

5 COMPONENTS OF WATER PURIFIER

5.1 Components Used

Major components used in the project include:

- Solar Panel
- Charge Controller
- Battery
- DC Water Pump
- Sediment Filter
- Activated Carbon Filter
- RO Filter
- Supporting Frame Structure

Each component plays a vital role in the system's operation.

5.1.1 Solar Panel

A solar plate, commonly known as a solar panel, is an essential component of the solar-powered RO water purifier system. It is responsible for converting sunlight into electrical energy, which is used to operate the water purification unit. The use of a solar panel eliminates the dependency on conventional electricity, making the system suitable for rural and remote areas where power supply is limited or unavailable.

The solar panel works on the principle of the photovoltaic effect. It is made up of multiple photovoltaic (PV) cells, usually composed of semiconductor materials like silicon. When sunlight falls on these cells, it excites the electrons and generates direct current (DC) electricity. This

generated electrical energy is either used directly to power the RO system or stored in a battery for continuous operation during low sunlight or nighttime.

In this project, the solar panel plays a key role in supplying power to the high-pressure pump and other electrical components of the RO purifier. The electricity generated ensures that the purification process runs smoothly without interruption. The integration of solar energy with the RO system not only improves efficiency but also makes the system eco-friendly and cost-effective.

The solar panel system also includes other supporting components such as a charge controller, battery, and connecting wires. The charge controller regulates the voltage and protects the battery from overcharging or deep discharge. The battery stores excess energy generated during peak sunlight hours, ensuring the system can function even when sunlight is not available.

The use of solar panels offers several advantages. It utilizes renewable energy, reduces electricity costs, and minimizes environmental impact by lowering carbon emissions. Additionally, solar panels require minimal maintenance and have a long lifespan, making them a reliable energy source. However, the system also has some limitations, such as dependency on sunlight and relatively high initial installation cost.

In conclusion, the solar plate is a vital part of the solar-powered RO water purifier. It provides a sustainable and efficient source of energy, enabling the system to deliver safe drinking water without relying on grid electricity, thereby making it an ideal solution for modern water purification needs.



Figure 5.1: Solar Panel

5.1.2 Charge Controller

A charge controller is an important component in a solar-powered system, responsible for regulating the flow of electrical energy from the solar panel to the battery and the load. In the solar-powered RO water purifier, the charge controller ensures that the battery is charged safely and efficiently, thereby improving the overall performance and lifespan of the system.

The main function of the charge controller is to control the voltage and current coming from the solar panel. Solar panels can generate varying amounts of voltage depending on sunlight intensity. Without a charge controller, this fluctuating voltage can damage the battery by overcharging or deep discharging. The charge controller prevents such issues by maintaining the battery within safe operating limits.

The working principle of a charge controller involves monitoring the battery voltage continuously. When the battery reaches its maximum charge level, the controller reduces or stops the flow of current from the solar panel to prevent overcharging. Similarly, when the battery voltage drops below a certain level, it disconnects the load to avoid deep discharge, which can damage the battery permanently.

There are mainly two types of charge controllers used in solar systems: PWM (Pulse Width Modulation) and MPPT (Maximum Power Point Tracking). PWM controllers are simple and cost-effective, while MPPT controllers are more advanced and efficient, as they optimize the power output from the solar panel.

In this project, the charge controller connects the solar panel, battery, and RO system. It ensures stable

power supply to the high-pressure pump and other components. It also protects the system from voltage fluctuations, short circuits, and reverse current flow.

The use of a charge controller offers several advantages, such as improved battery life, better energy management, and safe operation of the system. It also enhances the efficiency of the solar power system by ensuring that energy is used effectively.

In conclusion, the charge controller plays a crucial role in maintaining the stability and reliability of the solar-powered RO water purifier. It acts as a protective and controlling device that ensures proper energy flow, making the system safe, efficient, and long-lasting.



Figure 5.2: Charge Controller

5.1.3 Battery

A battery is a key component in a solar-powered system, used to store electrical energy generated by the solar panel for later use. In this project, an Exide battery is used to ensure continuous operation of the solar-powered RO water purifier. It provides a reliable power supply to the system during periods when sunlight is not available, such as during nighttime or cloudy conditions.

The working principle of the battery is based on electrochemical reactions, where chemical energy is converted into electrical energy. During sunlight hours, the solar panel generates electricity, which is regulated by the charge controller and stored in the Exide battery. When the solar panel is not generating sufficient power, the stored energy in the battery is

used to operate the high-pressure pump and other components of the RO system.

Exide batteries are widely known for their durability, high performance, and long service life. They are commonly used in solar applications due to their ability to withstand repeated charging and discharging cycles. These batteries provide a stable voltage output, which is essential for the efficient functioning of sensitive components like pumps and controllers in the RO system.

In this project, the Exide battery is connected between the charge controller and the load (RO unit). It stores excess energy generated during peak sunlight hours and supplies it when required. This ensures uninterrupted operation of the water purification system, even in off-grid areas where electricity supply is unreliable.

The use of an Exide battery offers several advantages, including high reliability, low maintenance, good energy efficiency, and long operational life. It is suitable for rural and remote applications due to its robust design and consistent performance. However, proper maintenance is necessary to ensure optimal performance, such as avoiding overcharging, preventing deep discharge, and ensuring proper connections.

In conclusion, the Exide battery plays a crucial role in the solar-powered RO water purifier by storing and supplying energy efficiently. Its reliability and performance make it an ideal choice for ensuring continuous and effective water purification in areas with limited or no electricity supply.



Figure 5.3: Battery

5.1.4 DC Water Pump

A DC water pump is a crucial component in a solar-powered RO water purifier system. It is responsible for moving water through different stages of the purification process and providing the necessary pressure required for Reverse Osmosis (RO) filtration. In this project, a DC water pump is used because it can operate directly on the electricity generated by the solar panel or stored in the battery, making it highly suitable for off-grid applications.

The working principle of a DC water pump is based on the conversion of electrical energy into mechanical energy. When direct current (DC) electricity is supplied to the pump, it drives a motor that rotates an impeller. This rotation creates suction that draws water into the pump and then pushes it forward with pressure. In an RO system, this pressure is essential to force water through the semi-permeable membrane, which separates pure water from dissolved impurities.

In the solar RO water purifier, the DC pump plays a vital role by ensuring continuous water flow and maintaining the required pressure for efficient filtration. Without sufficient pressure, the RO membrane cannot function properly, and the purification process becomes ineffective. Therefore, selecting a suitable DC pump with appropriate pressure and flow rate is important for the system's performance.

The use of a DC water pump offers several advantages in this project. It is energy-efficient, consumes less power, and is directly compatible with solar energy systems without the need for complex conversion equipment. It also reduces energy losses compared to AC pumps and is easier to control. Additionally, DC pumps are compact, reliable, and require minimal maintenance.

However, there are some limitations, such as limited pressure capacity in low-cost models and dependency on battery or solar power availability. Proper selection and maintenance of the pump are necessary to ensure long-term performance and efficiency.

In conclusion, the DC water pump is an essential component of the solar-powered RO water purifier. It ensures proper water flow and pressure required for

effective purification, enabling the system to function efficiently using renewable solar energy. Its compatibility with solar systems makes it an ideal choice for sustainable and off-grid water purification applications.



Figure 5.4: DC Water Pump

5.1.5 Sediment Filter

A sediment filter is the first stage in the water purification process and plays a crucial role in protecting the entire RO system. It is designed to remove larger suspended particles such as dust, sand, dirt, rust, and other visible impurities from the raw water before it enters the advanced filtration stages.

The working principle of a sediment filter is based on physical filtration. It typically consists of a fine porous material, such as polypropylene or spun fiber, which traps solid particles as water passes through it. The filter allows clean water to flow forward while blocking unwanted impurities. The size of particles it can remove depends on its micron rating, usually ranging from 1 to 10 microns.

In a solar-powered RO water purifier, the sediment filter acts as a pre-filter. It prevents large particles from entering and damaging sensitive components such as the carbon filter, RO membrane, and DC pump. By removing these impurities at an early stage, it improves the efficiency and lifespan of the entire system.

The use of a sediment filter offers several advantages. It enhances the overall water quality, reduces the load on subsequent filters, and prevents clogging or

damage to the RO membrane. It is simple in design, cost-effective, and easy to replace when clogged.

However, the sediment filter also has some limitations. It cannot remove dissolved impurities, chemicals, or microorganisms from water. Therefore, it must be used in combination with other filtration methods such as carbon filters and RO membranes for complete purification.

Regular maintenance of the sediment filter is essential to ensure proper performance. Over time, the filter may become clogged with accumulated particles, reducing water flow and efficiency. Periodic cleaning or replacement is required based on water quality and usage.

In conclusion, the sediment filter is an important component in the solar-powered RO water purifier. It acts as the first line of defense by removing larger impurities, protecting the system, and ensuring smooth and efficient operation of the entire purification process.



Figure 5.5: Sediment Filter

5.1.6 Activated Carbon Filter

An activated carbon filter is an important component in the water purification process, used to remove organic impurities, chlorine, bad taste, odor, and harmful chemicals from water. In a solar-powered RO water purifier, it acts as a secondary filtration stage after the sediment filter, improving water quality before it enters the RO membrane.

The working principle of an activated carbon filter is based on adsorption. Activated carbon has a highly porous structure with a large surface area, which allows it to attract and hold impurities on its surface.

When water passes through the carbon filter, contaminants such as chlorine, pesticides, volatile organic compounds (VOCs), and unpleasant odors are trapped, while clean water flows forward.

In this project, the activated carbon filter plays a crucial role in enhancing the efficiency of the RO system. It removes chlorine and other chemicals that can damage the RO membrane, thereby increasing its lifespan and performance. It also improves the taste and smell of water, making it more suitable for drinking.

Activated carbon filters are usually made from materials such as coconut shells, coal, or wood, which are processed to create a highly porous structure. These filters are compact, cost-effective, and easy to install in the purification system.

The advantages of using an activated carbon filter include effective removal of chlorine and organic impurities, improvement in water taste and odor, and protection of the RO membrane. However, it also has some limitations, such as inability to remove dissolved salts, heavy metals, or microorganisms, which is why it must be used along with other purification methods like RO.

Regular maintenance is required to ensure proper functioning of the carbon filter. Over time, the pores of the carbon get filled with impurities, reducing its effectiveness. Therefore, periodic replacement is necessary based on usage and water quality.

In conclusion, the activated carbon filter is a vital component in the solar-powered RO water purifier. It improves water quality by removing chemical impurities and enhances the overall efficiency and lifespan of the purification system, ensuring safe and better-tasting drinking water.



Figure 5.6: Activated Carbon Filter

5.1.7 Supporting Frame Structure

The supporting frame structure is an essential part of the solar-powered RO water purifier system, as it provides mechanical support and stability to all the components. It is designed to hold the solar panel, battery, filters, pump, and other components in a proper arrangement, ensuring safe and efficient operation of the system.

One of the important functions of the supporting frame is to hold the solar panel at an angle to receive maximum sunlight. Proper inclination of the solar panel increases its efficiency and ensures maximum power generation throughout the day. The frame is also designed to allow easy access to different components for maintenance and inspection.

CHAPTER 6 DESIGN AND MODELING

Design and Modeling:

System Design Overview

The Solar Powered Water Purifier system is designed by integrating two main subsystems:

- **Solar Power Generation System**
- **Water Purification System**

Both systems are interconnected to ensure continuous purification using renewable solar energy.

1.Solar Power System Design:

Power Requirement Calculation

Total Power Required

- DC Water Pump
- RO/UV System
- Miscellaneous losses

Solar Panel Selection

To support Watts load:

- Selected Solar Panel
- Output Voltage

Battery Design (Optional Backup)

Battery Capacity Calculation:

$$BatteryCapacity(Ah) = \frac{Load \times BackupTime}{BatteryVoltage}$$

2.Water Purification System Design:

The purification system is designed in multi-stage filtration:

1. **Sediment Filter** – Removes dust, sand, and large particles
2. **Activated Carbon Filter** – Removes Odor and chlorine
3. **RO Membrane / UV Chamber** – Removes dissolved salts and microorganisms

3.Electrical Modelling

Connections:

Solar Panel → Charge Controller → Battery → DC Load (Pump & RO)

Protection used:

- Fuse protection
- Proper grounding
- Insulated wiring

4.Design Considerations

- Low cost
- Easy maintenance

- Portability
- Energy efficiency
- Safety
- Scalability for future expansion

5. Mechanical Design

- Metal frame structure fabricated to hold:
 - Solar panel (top mounted for maximum sunlight)
 - Filter housing
 - Pump and battery
- Proper alignment angle
- piping used for water flow
- Leak-proof joints ensured

7 (Advantages, Applications, Limitations)

7.1 Advantages

The Solar Powered Water Purifier offers several advantages compared to conventional water purification systems. One of the most important benefits is the use of renewable solar energy as the primary power source. Solar energy is abundant, clean, and freely available, making the system environmentally friendly and sustainable. By utilizing sunlight to generate electricity, the system reduces dependence on conventional power sources and helps promote the use of renewable energy technologies.

Another major advantage is that the system is suitable for rural and remote areas where electricity supply is limited or unavailable. Many villages and off-grid locations face difficulties in accessing clean drinking water due to the lack of reliable electrical infrastructure. A solar powered purifier can operate

independently of the power grid, making it an ideal solution for such regions.

The system also provides low operating and maintenance costs. After the initial installation, the operating cost is minimal because sunlight is free. The only maintenance required is periodic cleaning of the solar panel and replacement of filtration components when necessary. This makes the system economically beneficial for long-term use.

The Solar Powered Water Purifier is also environmentally friendly. Traditional purification systems that rely on electricity may indirectly contribute to pollution if the electricity is generated from fossil fuels. In contrast, solar energy produces no harmful emissions, thereby reducing the environmental impact.

Another advantage is the portability and flexibility of the system. The purifier can be installed in various locations such as rural villages, agricultural fields, schools, and disaster relief camps. The system design can also be scaled according to the water requirements of different communities.

Finally, the system improves public health and quality of life by providing safe drinking water. Clean water helps reduce the spread of waterborne diseases and improves overall health conditions in communities. By combining renewable energy with effective water purification techniques, the Solar Powered Water Purifier becomes a reliable and sustainable solution for meeting the growing demand for clean drinking water.

7.2 Applications

The Solar Powered Water Purifier has a wide range of applications, especially in areas where access to electricity and safe drinking water is limited. One of the primary applications of this system is in rural villages. Many rural areas lack reliable electricity and proper water treatment facilities. A solar powered purifier can provide clean drinking water by using sunlight as the main energy source, making it a practical and sustainable solution for rural communities.

Another important application is in remote and off-grid locations such as forests, mountains, and islands.

These areas often have limited infrastructure and cannot support conventional water purification systems. Solar powered purifiers can operate independently without relying on the electrical grid, making them ideal for such environments.

The system can also be used in disaster relief camps and emergency situations. Natural disasters such as floods, earthquakes, and cyclones often damage water supply systems and electricity networks. A portable solar powered water purifier can help provide safe drinking water to affected people during emergencies.

Solar powered purification systems are also useful in agricultural fields and farmhouses where farmers may need access to clean drinking water while working in remote fields. The system can be installed easily and can operate using available sunlight.

Another application is in schools, small hospitals, and community centers located in rural areas. These institutions require a reliable supply of clean drinking water for students, staff, and patients. A solar powered purifier can help meet this requirement while reducing electricity costs.

Additionally, the system can be used in camping sites, military camps, and outdoor activities where access to safe drinking water may be limited. The portability and independence from electricity make the solar powered purifier a highly useful solution in such situations.

Overall, the Solar Powered Water Purifier has significant potential to improve water accessibility and public health in various locations where conventional water purification systems are difficult to implement.

7.3 Limitations

Although the Solar Powered Water Purifier offers many benefits, it also has certain limitations that must be considered during its design and implementation. One of the main limitations is the dependence on sunlight. Since the system relies on solar energy to operate, its performance can be affected during cloudy weather, rainy seasons, or at night when sunlight is not available. In such situations, the

system may require a battery backup or an alternative power source to maintain continuous operation.

Another limitation is the high initial installation cost. The system requires components such as solar panels, charge controllers, batteries, water pumps, and filtration units. These components increase the initial investment compared to traditional purification systems. However, the operational cost becomes lower over time because solar energy is free.

The efficiency of the system depends on proper installation and maintenance. Solar panels must be placed at the correct angle and location to receive maximum sunlight. Dust, dirt, or shading on the solar panel can reduce its efficiency and affect the system's performance.

The system also requires regular maintenance of filters and purification units. Filters such as sediment filters, carbon filters, and RO membranes must be replaced periodically to maintain water quality. If maintenance is not performed properly, the purification efficiency may decrease.

Another limitation is the limited water purification capacity. Small-scale solar powered purifiers are usually designed for households or small communities. They may not be sufficient for large populations without increasing the system size and cost.

8. Challenges Faced:

During the development of the Solar Powered Water Purifier project, several challenges were encountered in the design, assembly, and testing stages. These challenges helped in gaining practical knowledge and improving the overall understanding of renewable energy systems and water purification technologies.

One of the major challenges faced was the selection of appropriate components for the system. Choosing the correct solar panel capacity, water pump, and filtration components required careful analysis of power requirements and system efficiency. Incorrect component selection could affect the overall performance of the system.

Another challenge was the integration of solar power with the water purification system. Proper electrical connections between the solar panel, charge

controller, battery, and pump were necessary to ensure smooth operation. Any mistake in wiring or voltage regulation could damage the components or reduce system efficiency.

The availability of sufficient sunlight was also an important factor during testing. Since the system depends on solar energy, cloudy weather or low sunlight conditions affected the performance of the solar panel and reduced the power available to run the pump.

Mechanical assembly of the system also required attention. Proper mounting of the solar panel and filters was necessary to ensure stability and durability. Designing and fabricating the supporting frame structure took additional time and effort.

Another challenge involved water leakage and pipe connections during the installation of the filtration system. Ensuring leak-proof connections and proper water flow through the filters required careful adjustments.

Despite these challenges, the problems were gradually solved through testing, adjustments, and proper system design. Overcoming these difficulties helped improve the efficiency and reliability of the Solar Powered Water Purifier and provided valuable practical experience in renewable energy and water treatment technologies.

9 Conclusion

The Solar Powered Water Purifier is a sustainable and practical solution to address clean drinking water problems in electricity-deficient areas. With proper design and maintenance, it can provide long-term benefits at low operational cost.

The Solar Powered Water Purifier project successfully demonstrates the use of renewable solar energy to provide clean and safe drinking water. In many rural and remote areas, access to electricity and proper water purification systems is limited. This project provides a practical solution by combining solar power technology with an effective water purification process.

The system uses solar panels to convert sunlight into electrical energy, which is used to operate the water pump and purification unit. The water passes through

multiple filtration stages such as sediment filtration, carbon filtration, and RO or UV purification. These stages remove suspended particles, harmful microorganisms, and dissolved impurities, resulting in improved water quality.

The developed system is environmentally friendly because it uses renewable energy and produces no harmful emissions. It also reduces dependency on conventional electricity and helps lower operational costs. The project proves that solar energy can be effectively used for small-scale water purification systems, especially in off-grid locations.

The Solar Powered Water Purifier can be implemented in rural villages, agricultural fields, disaster relief camps, and other areas where electricity supply is unreliable. It provides a sustainable and reliable method for producing clean drinking water.

In conclusion, this project highlights the importance of integrating renewable energy technologies with essential services such as water purification. With further improvements and larger-scale implementation, solar powered purification systems can play an important role in addressing global water scarcity and improving public health.

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