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SOLAR POWERED RO WATER PURIFICATION SYSTEM

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ABSTRACT

This project focuses on developing a solar-based water purifier to address the issue of access to clean drinking water in areas where conventional energy is limited. The purifier uses solar panels to generate direct current, which is stored in a battery and used to power the motor that pumps water through a system of filters, pumps, and hoses to remove impurities. The use of solar energy makes the purifier accessible and affordable for all.

Keywords: water purifier, electricity issues, conventional energy, solar-based water purifier, solar energy, purification, affordable, solar panel, direct current, battery, filtering process, unwanted bacteria, dirt, motor, pumps, hoses, impurities, lifting water.

1. Introduction

1. Problem Statement

Access to clean and safe drinking water is a fundamental human right, yet many people in small villages and middle-class families around the world do not have access to it. Conventional water purifiers can be expensive and require electricity, which is not always available or affordable. This creates a serious problem, as impure water can cause life-threatening diseases. The aim of this project is to address this problem by designing a solar-based water purifier that is accessible and affordable for all humans.

2. Objective

We've decided on this design with the purpose to achieving these varied pretensions which we feel are veritably necessary to be addressed in this day and age.

- To provide pure water for all and it's affordable for everyone.
- Detaching sediments and

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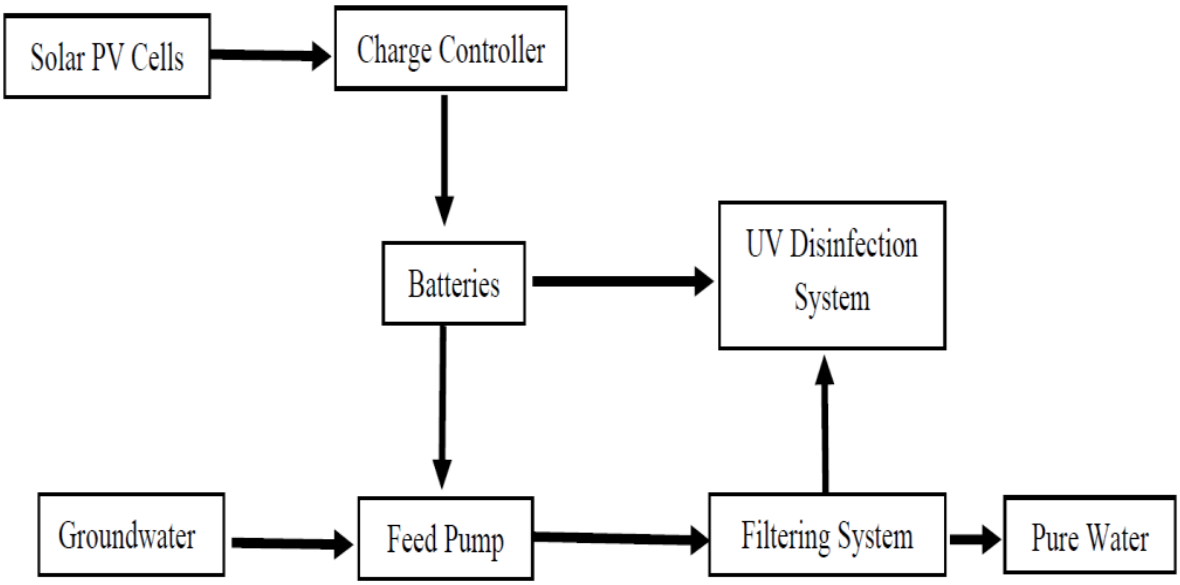
particulate matter from drinking water.



- Destroying pathogen, viruses, bacteria's and other diseases causing element from water, thus making it purified.

2. Literature Survey:

All over the countries, rural groups have adopted simple and simple and rudimentary remedy techniques that in particular intention at filtering out the visible impurities from the water collected from nearby assets. Even though those traditional methods are expedient and can remove sure sort's particles from the water, they don't offer water necessarily of what could can be taken under the present situation of drinking quality water. This is ideal process for rural communities and in most cases with easy step of disinfection they may yield water loose from pathogens. There are several methods.

a) Filtration along Winnowing Sieve
b) Filtration through Cloth
c) Filtration through Clay Vessels

a) Filtration along Winnowing Sieve: This type of filtration is used when the water source is polluted by air-borne impurities such as dry leaves, stalks, and coarse particles. The raw water is passed through a winnowing sieve, and the impurities are filtered. This kind of filter is widely used in villages of the Bamako area, Mali. This method cannot be used when the raw water is highly turbid or muddy, since the sieve cannot filter fine suspended particles in raw water.

b) Filtration through cloth: In villages they use white skinny cotton material or a discarded garment is used as the filter medium. This filter can clear out uncooked water containing such impurities as plants bacteria, insects, dust particles or mud debris. This purification process suspended particles present in water may be removes in only small amount. These practices of fabric filtration are pretty common in villages in India.

c) Filtration through Clay Vessels (Earthen Pot): In Clay vessels with a appropriate pore size are every so often used to filter fairly turbid water. Muddy water is gathered in massive clay jar or pot and allowed to rest on lower surface of pot,

then the water in jar will trickle through the porous clay wall in jar. The trickled water is composed in a vessel (clay pot) through setting it at lowest of the porous clay jar.

Sourav Kumar Ghosh and Md. Mamunur Rashid et. al. [1], (2020), This research work uses solar energy as an energy source and stores it in a battery which is a free source of energy. This energy is then used by inexpensive heating coils to heats the water to a specific temperature (below boiling points).After condensation, the cold water undergoes further purification through the filtering chalk. At this stage, the water condenses again to give water room temperature. Through this process, we obtain clean drinking water. We went through almost at every stage of a product development process, from gathering customer requirements to finalizing the design. [1].

K. Dikgale, D.F. Ntobela, B.G.V. Mendes, et. al.[2], proposed that solar-powered water purification systems is thus regarded as an important means of producing clean water. Solar energy poses no polluting effect and has become a dependable energy source for usage. The design of a solar powered water purification system is based totally on the thermal method by using the thermal heating system principle which converts sunlight rays into heat. The most vital aspect is the absorption of heat to induce evaporation of water. Research shows that flat plate collectors produce heat at relatively low temperatures and are commonly used to heat liquids. A solar-powered water purification system consists of a solar collector that absorbs sunlight to ensure vaporization, which is the first stage of purifying and a filter that removes contaminants. Four different concepts have been developed.

Gazi Nazia Nur, Mohammad Ahnaf Sadat et al. [3] proposed that Conventional energy sources are limited and they cause environmental pollution. By using a renewable energy source as solar power to purify water, these problems can be avoided. Solar water purifier is an advancement of current water purification system. Design methodology of the solar water purifier is presented in this paper. Solar water purifier takes solar power as energy source and stores energy in a battery. Main components of solar water purifier are solar panel, battery, heating coil, filtering chalk, double layer condenser and several water vessels. This purifier uses filtering mechanism to remove dirt from water and boiling mechanism to kill organisms. Through this process, pure drinking water is achieved. [3]

Lamma OA & Abubaker M. Outhman et al. [4] proposed that impact of reverse osmosis on purification of water Raw water reverse osmosis technology has taken many leaps towards the development of energy efficient and high yielding systems. The reduction in energy consumption, improvement in membrane life and increase in energy recovery emerged as the primary criteria for research in this field. The key objective of the work involves the optimization of the variables involved in the pre-treatment process of different water sources (pond, canal and surface water) reverse osmosis plant which would lead to an increase in the membrane life by reducing solids content of the raw water. Experiments were carried out to ensure maximum total solids reduction and also reduction of different chemical parameters (BOD, TDS and Bacteria). These parameters were found to be desirable for the discharge from the pretreatment to be fed into the reverse osmosis part of the plant and RO water plant is used drinking purpose and free from contaminants.[4]

Yogita V. Gaikwad, Pooja V. Gavande et al. [5] proposed that a reverse osmosis

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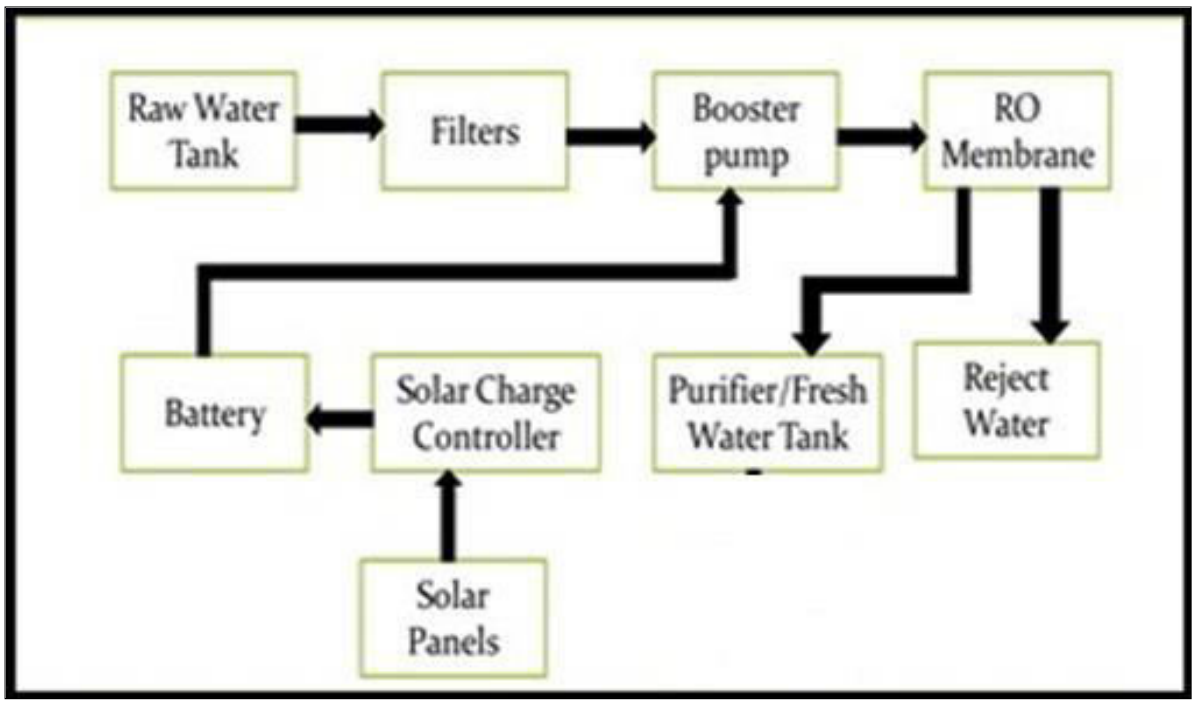
purification process. This system contains mainly power supply circuit, purification circuit and control circuit. Power supply consists of solar panel, charge controller, battery and inverter. Purification unit consist of booster pump, Reverse Osmosis system and control circuit contains sensor, microcontroller and relays. High pressure is created by booster pump to carry out reverse osmosis process. The microcontroller keeps watch to level of the water tank and prevents it from the overflow. By using this process, we obtain pure water in the water tank.[5]

Dr.S.Prakash, Deepak Toppo. et al., (2017), [6] The basic principle behind this project is reverse osmosis. The solar radiations are collected by solar panel. This energy is then stored in a battery. The battery is connected to the purification unit through an electromagnetic relay. The purification unit consists of high-pressure motor, reverse osmosis system and the water tank. The high pressure creates the necessary pressure required to carry out reverse osmosis. The microcontroller 8051 keeps a watch to the level of water in the water tank and prevents it from over flow. Through this process we obtain the purified water in the water tank. [6]

3. Methodology:

3.1 Working



As shown in the block diagram. Our major Component of this purifier is filters, Solar Panel, booster pump, Solar Charge controller, Reverse Osmosis Membrane etc. In this mechanism purifier is completely dependent on solar panel power. Solar power is used as energy resource and energy is stored in a battery.

The solar panel are made of photovoltaic cell which is responsible for converting the sun energy into electrical energy the energy which is obtain from solar panel are stored in battery where the solar charger controller regulates the amperage and voltage that is delivered by solar panel to maintain the batteries load without getting overcharged.

The power source then turns on the filters and the motor rotor rotate, pulls the eccentric swing wheel to make eccentric

movements, and turns the water scaffold assembly of three cameras connected near the eccentric tread wheel to reverse, driving the diaphragm. The continuous rotation of the engine enables the diaphragm of the RO booster pump to continue to replicate, fulfilling the purpose of pumping and increasing the water after which it enters. The RO membrane can remove all majority contaminants from pushing the water through semi permeable membrane removes all impurities of water.

The membrane consists of 3 layers the first layer is made of polyamide sheet the size of layer is 0.2 microns it's does not enter any kind particles and polysulfide layer can removes the nutrients, bacteria, chemical, virus which are present in water the last is polyester base where the purified water pass. After the purification process dirty water gets separated as well as clean water gets separated.

3.2 What is a solar microgrid and how does it work?

1. By converting solar radiation into electrical energy, all solar PV panels in the array generate power.

2. The electricity generated by the array of panels is sent to the Power Conditioning Unit, which is a central controller (PCU).

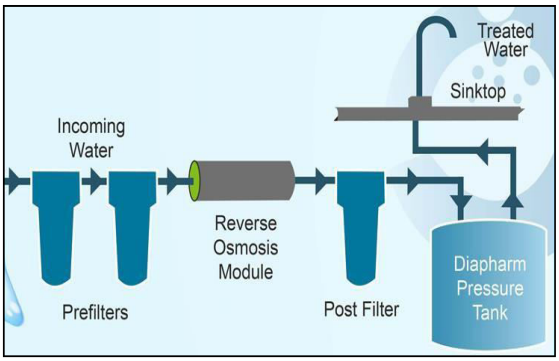
3. The PCU is in charge of controlling, regulating, and directing the electrical energy that is transmitted from the array, as well as supplying electricity directly to homes, businesses, offices, and street lights.

4.During the day, if the electricity generated is not used or if there is extra power, the PCU sends it to the battery bank, which stores it. After then, this energy might be utilised at night (after the sun sets).

For local power usage monitoring, the microgrid and battery bank are connected to a computer. This information can be accessible from a remote location with the installation of a modem, removing the requirement for local people to monitor the system.

3.3 Working of Solar RO

The SOLAR RO system is made up of two parts: a power generation unit and a desalination unit. Because the RO unit requires a stable power supply, the system's



electricity will be supplied by the solar PV array, and batteries will be linked to provide that power.

The PV generated energy is stored in a battery bank. The loads are powered by the

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stored energy. On the brine side, the RO desalination process comprises of a high-pressure pump, membrane unit, and pressure control valve.The solution is forced against the membrane by a pump, and water molecules pass through the membrane, reducing the concentration of the solute known as permeate, while the remaining water, which contains high salt concentrations, is rejected as a waste known as brine. The brine side valve is used to manage the amount of brine discharged as well as the system pressure.

Configurations of Solar RO Systems

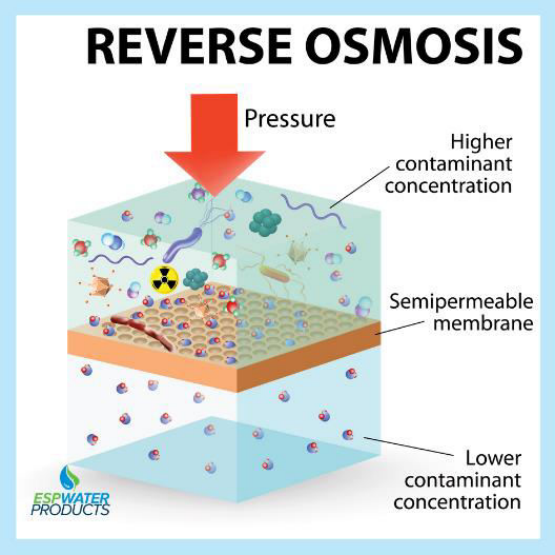
All instruments and parts are housed in a container, which has a solar electric panel mounted on top or on one side as needed. The biggest advantage of such solar PV systems is that they can operate 24 hours a day, seven days a week without the use of a diesel generator or an expensive power source.

3.4 How Does RO Works:

Reverse osmosis is a treatment technology with continuous operation that uses pressure to pass source water through a thin membrane and thereby separate impurities from water.

Reverse Osmosis (RO) works by reversing the principle of osmosis, the natural tendency of water with dissolved salts to flow through a membrane from lower to higher salt concentration. This process is found throughout nature. Plants use it to absorb water and nutrients from the soil. In humans and other animals, kidneys use osmosis to absorb water from the blood.

The reverse osmosis principle reverses that process. In a RO system, pressure —



usually from a pump— is used to overcome natural osmotic pressure, forcing feedwater with its load of dissolved salts and other impurities through a highly sophisticated, semipermeable membrane that removes a high percentage of the impurities. The product of this process is highly purified water.

4. Construction Details:

4.1 Solar Panel:

In this model, solar panel is used for collecting the solar energy. Solar panel are made from photovoltaic cell. The amount of power which is completely depend on the intensity of light. We are using a mini solar panel of 20-watt for a 12-volt battery that is charged with the help of sunlight.

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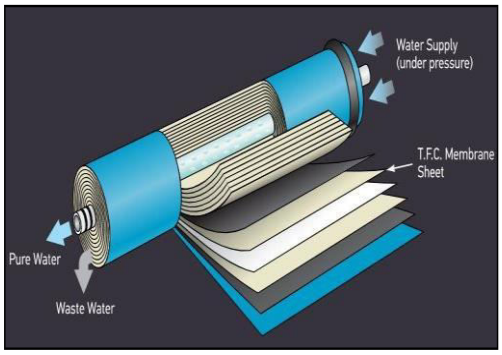
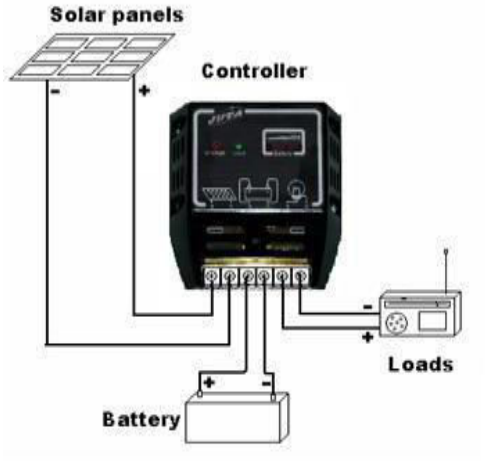
Being light in weight, this portable solar panel finds many applications or uses. The panel is specially designed to charge small batteries up to 10 Ah or 10,000 mAh. Mini solar panels are defined by their size (dimensions), which ranges from 0.6 x 2.55 inches to 14 x 18 inches (equivalent to 1.7 sqft, i.e., comparable to a regular medium sized home mirror).

4 2. Solar Charger Controller

A solar charge controller is an electronic device that controls the power supplied to the battery from the solar panel.





This ensures that the deep cycle battery is not recharged during the day and energy is returned to the solar panel during the night so that the battery is not drained. Some charge controllers are available with additional features like lighting and load control, but power management is the main focus.

4.3. Booster Pump

Booster pumps are used to increase water pressure. Usually, the osmotic pressure is higher. Purification requires that water flow from a high concentration to a low concentration.

Therefore, in order to perform the reverse osmosis process, the high-concentration lateral pressure must be higher than the osmotic pressure

4.4. Reverse Osmosis Membrane

Reverse osmosis (RO) is a special type of filtration that uses a semipermeable

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membrane with pores small enough to allow pure water to pass and rejects larger molecules such as dissolved salts (ions) and other impurities. RO units purify water by passing it through a thin, semi-permeable membrane to remove suspended and dissolved impurities and pollutants.

There are three types of filters in a standard three stages reverse osmosis system

• Sediment filter that traps larger particles suspended in water, such as dirt and rust

•The Carbon filter removes VOC, Chlorine and other small contaminants from water.

•Semi-Permeable reverse osmosis membrane that removes virtually all remaining.

4.5. Storage Battery

It is an essential part of the system. Solar radiation intensity varies from season to season as per the atmospheric condition. It protects the impurities pump from over the voltage by providing Constant voltage of 12V. It has an output voltage of 12v and an output current of 5Amp.

5. Design Calculations

5.1 Design Solar Parameters

The designs of panel are mainly as follows which affects the collector panel performance.

Power for Application: The power required for a particular application directly affects the manifold panel. The larger the panel area, the greater the power received and the greater the cost. The maximum power of this panel is 18W.

Angle of Latitude: The angle of latitude is the angle at which the panel should he kept SO as to absorb maximum solar energy. The angle of latitude for any location is the angle between the equator plane of earth and line joining a particular point on earth's surface and the equatorial center of earth.

For determining angle of latitude following procedure is adopted

1. Mark all the three points'

- Earth's center point
- Equatorial plane line
- Location for which panel is to be designed on world map

2. Connect the earth point with location point

3. Calculate the angle included between equatorial plane line and earth's center point.

As shown in the map for Wardha dist. It is equal to 200 therefore collector should be placed at 200 facing towards south.

Average Power Intensity

The average power intensity for any locality is the unit power collecting per day. Reference to the map shows the global radiation of India.

For Vidarbha

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- Average global radiation = 6.1 KWh/sq.m.day 1 KWh/sq.m.

= 3.6 MJ/sq.m. day Avg.

global radiation = 6.1 * 3.6 = 21.96 MJ/sq. i.e (21.96 x 106) / (24x60)

= 15250 J/sq.m.mm 5250/60

= 254J/sq.m.sec U/sec

= 1W.

Therefore avg. global radiation= 254 W/sq.m.

Angle of Incidence :

Its depends upon time of day also the angle of sunrays makes horizontal Surface measured w.r.t ,

As the sun travels the angular distance of 1800 for 12 hrs.

it travels at an angular speed of 180/12 = 150/hr.

The ideal angle of incidence is the angle which makes the sun at angle of Latitude (Q) & incidence =900

As angle of latitude = Q = 200

Ideal angle of incident = 900 – 200

=700 Area of Collector:

The area of collector mainly influences the power generated by a collector.

While designing it following procedure is

followed. in = ibn x A x COSØ

Where, in = power developed

A = area of collector.

Ibn = Average solar intensity

As ideal angle of incidence is

700 In = Ibn x A x COSØ 6

= 254 x A x cos 70

Therefore A = 0.069066 m

Consider it is a rectangular panel having side ratio as

1:3 I 2 = 0.069066 = 0.325m = 32.5

B=3 x I=47 cm

Panel area = 32.5 x 47 =1527.5 cm2

Discharge of Water: Q = AREA X VELOCITY

Now area = 0.01 x 0.01 = 0.0001 mm2

Now find velocity of water through pipe,

Hf= (4 x f x L x V2)/Area of c/s x 2g

Hf= difference of pressure head=4

F = coefficient of friction = 0.009

L = total length of pipe = 10.0584 m

V = velocity of water 4 = (4 X 0.009 X 10.058 X V2) / 0.0001 x 2 x 9.8

V = 1.4721 m/s

Q= 0.0001 x 1.4721

Q = 0.000014721 m3/s => Q = 0.01472 litre/s

6. Advantages and Disadvantages:

6.1 Advantages of Solar-Powered RO Water Purifiers:

1.Renewable Energy: Solar-powered RO water purifiers use renewable energy, which reduces the dependence on fossil fuels and helps to mitigate the effects of climate change.

2.Cost-effective: Since solar power is a free and abundant resource, it can significantly reduce the operational costs of water purification plants, especially in areas where electricity is unreliable or expensive.

3.Off-grid access: Solar-powered RO water purifiers can provide access to clean drinking water in remote and off-grid locations, including disaster-prone areas where access to clean water is often disrupted.

4.Health benefits: RO water purifiers remove harmful contaminants such as bacteria, viruses, and other impurities, thereby providing clean and safe drinking water.

5.Economic opportunities: The production and installation of solar-powered RO water purifiers can create economic opportunities in areas where clean water is scarce. Additionally, the use of solar power can reduce the operational costs of water treatment plants, which can lead to lower prices

7.1 Disadvantages of Multipurpose Agricultural Operated Machine

6.2 Disadvantages of Solar-Powered RO Water Purifiers:

1.Initial cost: The installation cost of a solar-powered RO water purifier can be relatively high compared to conventional water treatment systems. This can make it difficult for some communities to adopt the technology.

2.Weather dependency: Solar-powered RO water purifiers rely on sunlight to generate electricity. Therefore, they may not be suitable for regions with low sunlight or extended periods of cloudy weather.

3.Energy storage: Solar-powered RO water purifiers require energy storage systems, such as batteries, to provide a continuous supply of clean water, especially during periods of low sunlight or at night. These energy storage systems can be expensive and require maintenance.

4.Maintenance: Solar-powered RO water purifiers require regular maintenance to ensure optimal performance. This can be a challenge in remote or off-grid locations where skilled technicians may not be readily available.

6.3 Application

Applications for Solar RO and UF Systems

• Agriculture

• Brackish Water

• Disaster Relief

• Drinking Water

• Groundwater Remediation

• Irrigation

• Low Energy

• Marine

• Military

•Reverse Osmosis

•Ultrafiltration

•Solar Deep-Well Reverse Osmosis Plants

•Solar RO plants for brackish water from deep wells with TDS up to 15,000 ppm

Applications: towns and villages, oil fields, work camps, small factories, hospitals, and breweries.

•Solar Surface Water RO Plants

•Solar RO plants for brackish and polluted surface water up to 15,000 TDS and 1,500 TTS. The S-ROC has two plants in one: MF/UF and RO plants.

Applications: Towns/Villages along polluted rivers, lakes, small factories, hospitals, breweries.

7. Conclusion

The purpose of this project was to develop s solar-powered water purification systems. Through a literature review, several existing concepts were identified. These existing concepts (namely solar water distillation method, parabolic dish configuration, and heating coils solar water purification system) were used to develop the concepts presented in this paper. The paper focuses on the design systems that could purify biologically contaminated water by using the thermal method.

This machine is the most convenient and accessible for the disinfection of water where power supply and ways to purify water is unmapped. The simple mechanism and integrated structure rhythmically convert the solar energy through motor and assists the filtration process devoicing water from bacteria, insoluble, minerals and other unwanted viruses giving potable water.

It is inexpensive and uses solar energy to purify abundant water, so it can be used anywhere there is no electricity. This could be an area for future research in this era. This type of Water Purifier is not yet on the market. Therefore, we believe that if solar water purifier is effectively implemented by removing limitations so they will be able to attract customer from all sector living in urban and rural areas.

8. Future Scope:

Solar powered reverse osmosis systems are a new concept in Indian water purification industry. Renewable energy resource such as solar energy is constantly replenished and will never run out, so that during night time we won't be running out of power. Reverse osmosis water systems can purify water from any source and can deliver safe drinking water. These systems are highly suitable for military camps, village areas and fairs and tourist places where arrangement of temporary drinking water is a prime requisite at minimal price.