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PV Integrated Water Purifier

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Abstract: This study demonstrates the construction of a solar power-based water purification system. The fundamental principle is reverse osmosis. Solar panels collect solar radiation, storing the energy in a battery. Using an electromagnetic relay, this battery is connected to a purification unit. The system utilizes sediment filtration supplemented with ultraviolet light for effective filtration. This project aims to provide minimal expenses for purified water in the village areas. This report offers entire project information regarding solar cells, construction layout, and hardware design.

Keywords **– PV Cell, Reverse Osmosis, Solar Energy, Solar Panel, Water Purification.**

1. Introduction:

It is generally acknowledged that solar energy is a renewable resource. The sun produces its energy through a nuclear reaction. During this process, 650,000,000 tons of hydrogen were transformed into helium every second. Large amounts of heat and electromagnetic radiation are produced during this process. Solar energy can be stored using a variety of collectors, such as flat plate collectors. Today, there is a severe threat to drinking water supply across our nation. The water supply could be more reliable; it typically has a blackish colour and is polluted. In many tribal communities or villages, access to clean drinking water is a big issue. We also know that various kinds of diseases can occur from drinking water. Some are mentioned below.

Type	Cause	Disease
Chemical	Lead:	Infants & Children: Delays in physical or mental development. Adults: Kidney and high BP
	Arsenic:	High risk of getting cancer, skin damage or circulatory system problems.
	Fluoride:	Bone disease: Pain and tenderness of bone, Mottled teeth of children.
Microbial	Bacterial Infection:	Typhoid, Cholera etc.
	Viral Infection:	Infectious Hepatitis (Jaundice)
	Protozoa Infections:	Amoebic dysentery

There are numerous answers to this issue, but they take time and cannot be guaranteed. Considering this, a solar water purifier has been made, where solar energy will do water purification. Solar energy is abundant, cheap and easy to handle. The main principle of this water purifier is reverse osmosis. Without electric power, the stored solar energy will compensate for the required power, and water can be purified quickly. This purifier can easily be used in rural areas where electricity has yet to be reached. This purifier can be used after reducing the salt level of seawater. It can be used easily in any area where natural disasters have affected everything. A microcontroller has been used here to monitor the water level inside the purifier, which will also prevent water from overflowing.

2. LITERATURE REVIEW:

In 1990, Hasan conducted research on contact aeration for iron removal technology. The iron removal process made use of the catalytic capabilities of ferric iron. Again, it was demonstrated theoretically in this experiment that keeping the ferric iron concentration high can significantly reduce the volume of the aeration tank, which was in line with the oxygenation rate equation. Ferric iron is very effective at reducing reactor volumes at lower pH values. It is advised to recycle the ferric sludge in order to maintain the reactor's high ferric iron concentrations [1].

In 1992, William, et al. looked at how dissolved organic carbon affected iron removal during water treatment. He used the oxidation and coagulation technique to get rid of the iron. Humic, fulvic, tannic, and oxalic acids in the organic content were calculated. The oxidizing agents were free chlorine, chlorine dioxide, and potassium permanganate [2].

Research on the utilization of oxidation-reduction potential to control the biological removal of iron from drinking water was done by Catherine in 1988. This study processed raw water at a pH of 5.7 in a pilot plant to produce drinking water and remove iron organically. Using oxidation-reduction potential as a tool, a biological filter was used to evaluate and establish the relationship between dissolved oxygen and residual iron concentration in the infiltration [3].

Tomotada conducted a study on the existing approaches to biological remediation in 2001. He used fluorescent in situ hybridization, in situ PCR, and the technique of quantitative PCR to eliminate pollutants through bioremediation. Bacteria and pathogens, which are directly connected to another type of pollution degradation, are particularly well-detected and rearranged by this method [4].In 2005, Choo et al. investigated membrane fouling and the removal of iron and manganese in ultra-filtration. He

also looked at removing any remaining chlorine from pre-chlorination, which is chosen as a practical method for producing safe drinking water. The oxidation of iron and manganese, which was also clearly seen at the microscopic level and the procedures for stopping the membrane degradation were provided, was what caused the fouling of the membrane [5].

3. ESSENTIAL TERMS:

3.1 PV CELL:

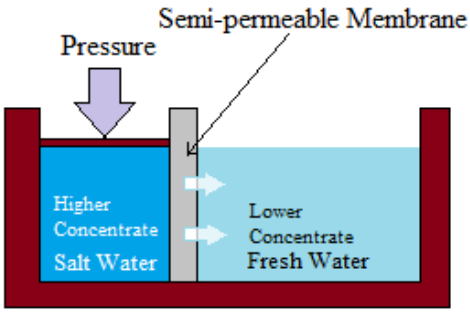
Currently, renewable energy is a significant topic of discussion. Solar power is one of the primary sources of renewable energy. Due to its potential being 20,000 times greater than global consumption, solar energy has the potential to become a significant source of power in the near future. According to Azhari et al., the annual average solar radiation for each day ranges from 4.21 to 5.56 kWh/m^2, with the highest expected levels of solar radiation occurring in August and November, up to 6.8 kWh/m2, and the lowest levels occurring in December, at 0.61 kWh/m2 [6]. Solar energy cannot be produced on a big scale, so the sun's energy is used here. The total power demand is 10^{13} worldwide of all needs of civilization, and the solar power on earth's surface is 10^{16} watts. So we can see Sun gives us 1000 times more power than we need. On an average sunny day, energy radiated by Sun on earth surface is 1Kw/$m^{2,}$ which can be used for various purpose of electrical energy. Using solar plate, solar energy can be collected and stored in a battery. The battery is used to store the solar energy that has been captured. This energy can be utilized to purify water when there is a lack of electricity, such as in rural, off-the-grid, and disaster-affected areas [7–9]. The charge controller here manages the amount of solar energy needed to be stored in the battery.

One of the best methods for using solar power to create electricity is solar PV technology, which turns sunlight into direct current in solar cells or PV cells [10-11]. Devices based on electronic semiconductors, mainly but not exclusively crystalline silicon (c-Si) or thin-film semiconductor materials, are used in PV energy conversion. Mono-crystalline and multi-crystalline solar modules are the primary crystalline material types used in constructing (c-Si) based solar systems. Single-crystal semiconductors are comparable to polycrystalline materials in terms of electrical performance (20% efficiency). However, mono crystalline PV modules are unprofitable because of the high cost of crystalline wafer-based technology [12-13]. Amorphous silicon (a-Si), copper indium gallium selenide (CIGS), or gallium arsenide (GaAs) are examples of additional semiconductor materials that are frequently used in the structure of thin film technology. A traditional (c-Si) solar cell is substantially thicker than a thin-film solar cell. Thin-film modules can be light and flexible due to the film's thickness, which ranges from a few nanometers (nm) to tens of micrometres (m). Additionally, thin-film technology is typically more affordable than (c-Si) wafer-based technology. One of the most popular thin-film technologies, with a cell efficiency of (5-7%), is the (a-Si) solar cell. The efficiency rises to 8–10% with a double and triple junction design. When compared to the (c-Si) module, (a-Si) thin film is less efficient. Additionally, (a-Si) thin film is vulnerable to degradation due to (a-Si) reacting with the environment, such as with air or water vapour.

Fig 1: Solar Panel

3.2 REVERSE OSMOSIS:

Reverse osmosis is a technique that uses pressure to force water through an impermeable membrane to remove the vast majority of pollutants from water. Water flows from a lower concentration region to a higher concentration region when a semi-permeable membrane separates two solutions with differing concentrations. The name of this procedure is osmosis. [14-16] Osmotic pressure is the factor behind this. The solvent will flow from a higher concentration to a lower concentration if a hydrostatic pressure applied to the side with the higher concentration is greater than the osmotic pressure. Reverse osmosis is the name of this method. As a result, salt water and clean water are separated throughout the reverse osmosis process.



Reverse Osmosis

Fig 2: Reverse Osmosis

3.3 ULTRAVIOLET:

Ultraviolet is the sort of electromagnetic energy that cannot be seen by humans and is invisible. It can occasionally disrupt bonds between atoms and molecules because it has more incredible energy than visible light, which changes the chemistry of the materials exposed. Fluorescence is also produced by UV light. Ultraviolet (UV) light is distinguished in four groups. These include UV-C (200-280 nm), UV-B (280-315 nm), and UV-A (315-400 nm) in addition to vacuum UV. Vacuum UV and UV-C are absent at the earth's surface because various gases, including oxygen and ozone absorb them. For life to have evolved on Earth, atmospheric oxygen and a stratospheric ozone layer had to emerge. The ozone layer protects the earth's surface from dangerous UV rays.

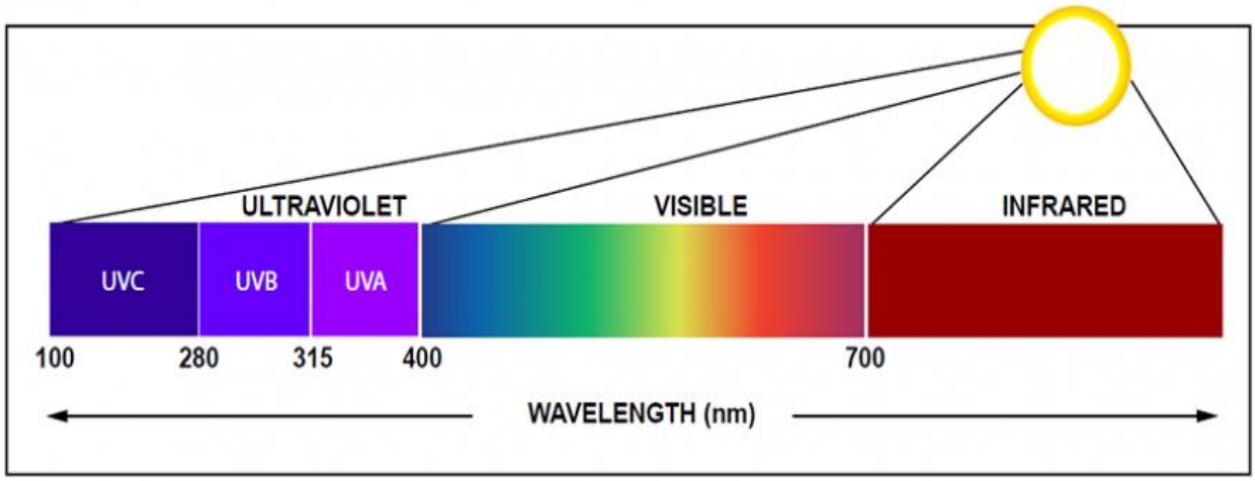


Fig 3: Ultraviolet Wavelength (Source: Internet)

4. MATERIALS & SYSTEM LAYOUT:

The materials used in this process are,

- Solar Panel
- Charge Controller
- Battery
- Inverter
- Water Tank
- UV Lamp
- RO

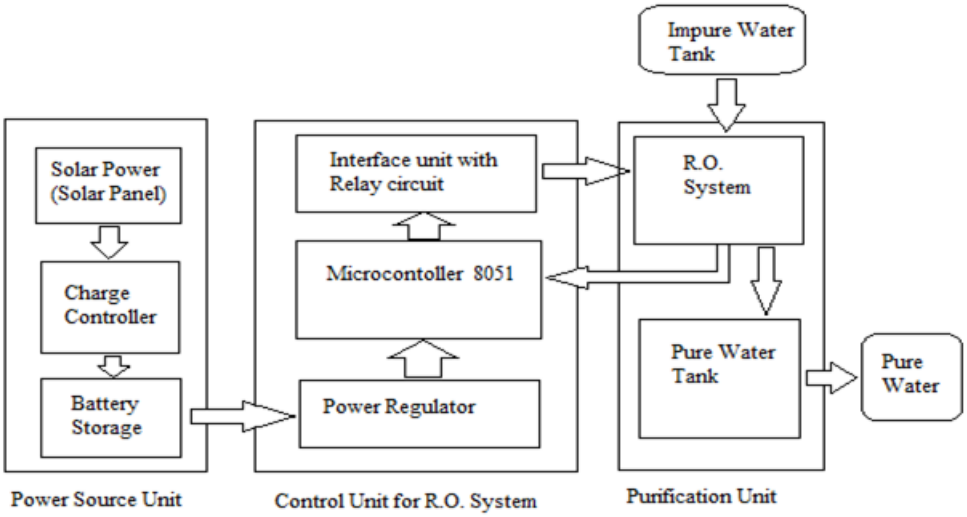


Fig 4: Block Diagram of Solar Energy Based Water Purification

In the above block diagram, three significant units have been shown. The first one is a Power source unit, followed by a Control Unit. Finally, there is a Purification Unit. Inside the Power source unit is a solar panel that absorbs solar radiation. This solar power is now stored in a battery using a charge controller. The charge controller also prevents the battery from getting overcharged. Next is the control unit for the RO system. The stored solar power feeds energy into the control unit. Inside the control unit, a power regulator regulates the received power and converts the voltage level. This is necessary for the microcontroller to operate. There is a microcontroller, which is generally used to control water levels. Next is the purification unit, which consists of a high-pressure motor, RO system and water tank. With the help of an electromagnetic relay, the battery is connected to the purification unit. At first impure water comes to the RO system with the help of a high-pressure motor. It gets purified and comes into the pure water tank. From which we can receive and store pure water.

5. HARDWARE DESIGN:

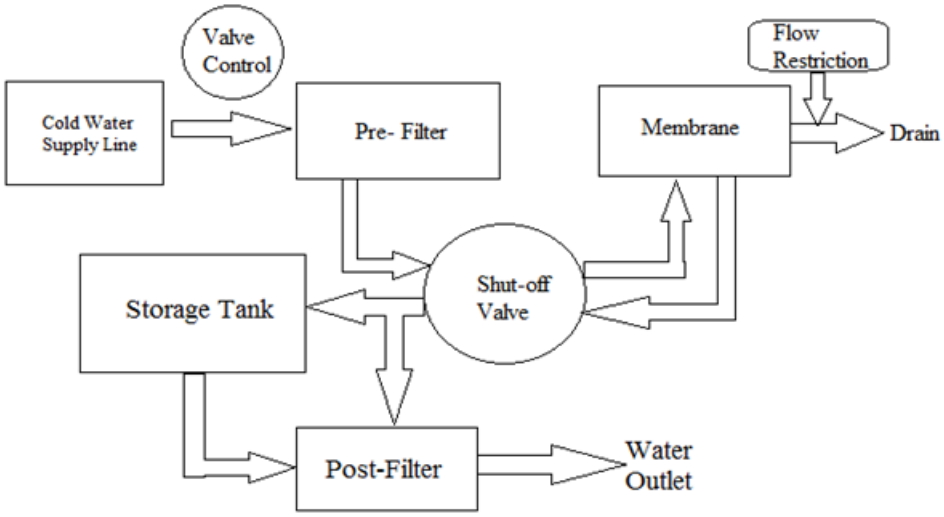


Fig 5: Hardware Design Block diagram

At first solar panels collect solar power. Now using a charge controller, this energy is stored in a battery. Here the charge controller also prevents the battery from getting overcharged and using an electromagnetic relay connected to the purification unit. The battery is connected to the voltage regulator, which converts 24V to 5V, which voltage is required for the microcontroller. The purification unit comprises a water tank, a Reverse Osmosis system and a high-pressure motor. This high-pressure motor provides the necessary pressure for the reverse osmosis process. The water level in the water tank is detected by the 8051 microcontroller, which also prevents water from overflowing.

6. POWER SUPPLY CIRCUIT:

This study uses a 12V, 50W solar panel and a 12V, 7.5A battery. Through a charge control relay, the solar panel charges the battery. The battery can withstand a maximum charge of 14.2 V. Over the storm, a charge controller has been installed to stop it from being overcharged or at a voltage higher than 14.2V. This circuit uses a diode to keep the current flowing in a single direction [17-19]. The voltage regulator circuit has been employed, which changes 12V to +5V because the microcontroller only accepts a constant +5V. The microcontroller uses a regulated DC supply, whereas the motor and relay use an uncontrolled one.

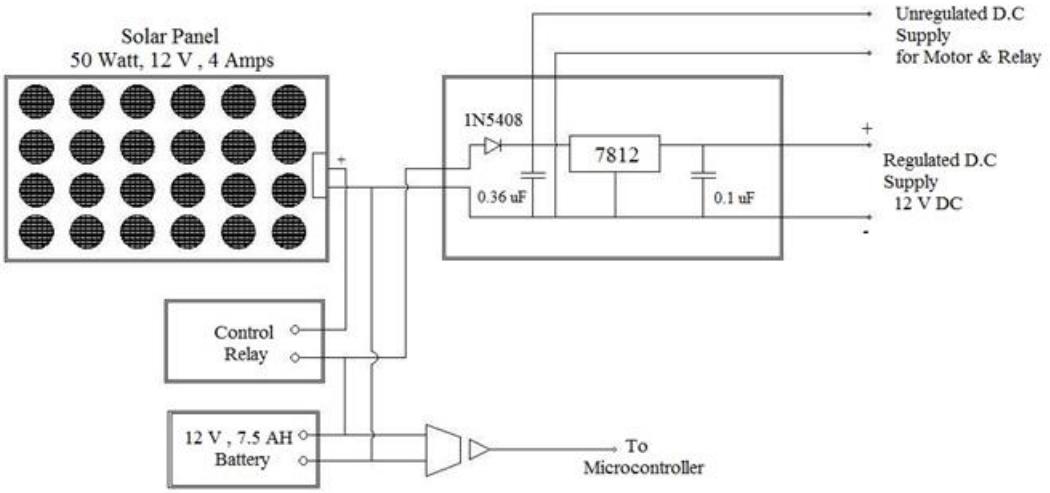


Fig 6: Power Supply Circuit

7. HARDWARE KIT:

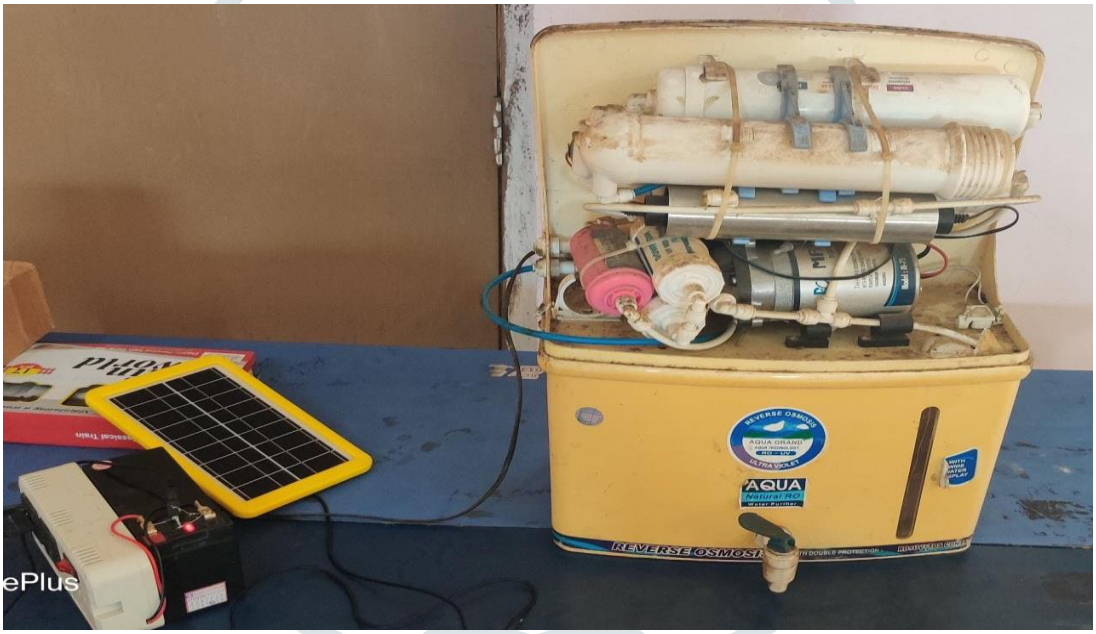


Fig 7: Hardware Kit

8. CONCLUSION AND FUTURE SCOPE:

Solar energy may be employed anywhere; when there is no access to power, it can be used to purify water, which is inexpensive and plentiful. In this case, the microcontroller is also utilized to prevent water overflowing. In addition, reverse osmosis is an effective disinfectant process. This project has no ongoing costs and only capital expenses. It will therefore prove helpful shortly. Solar water disinfection (SODIS), solar distillation, solar water pasteurization, and solar water treatment systems are the four primary methods of solar water treatment. While most of these technologies are recent additions to the solar energy concept, some have been around for a long time. These technologies are known for being efficient and are generally relatively straightforward to understand.

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