REVIEW ON SOLAR WATER PURIFIER FOR SUSTAINABLE SOLUTION OF WATER CRISIS

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ABSTRACT

Safe drinking water is not only the basic need of human beings but also for the domestic animals. Microbial, lead and mercury contamination of drinking water are the major health hazards. Most of the peoples in developing countries are facing the problem of safe, clean and drinkable water. For daily uses including drinking, washing, cleaning purposes, rural peoples are generally depended on rivers, lake water as well as ground water. But the water obtained from the above sources contaminated with various harmful chemicals, bacteria and other water borne diseases. Different water purification technologies have been developed in the recent years which are beneficial to us. Solar based technologies which are used for water purification in household or industrial areas mainly focused here. From various cited literature, it is also observed that, there are much scope in membrane based water purification system along with Arduino UNO by using solar energy and found useful in removing chemical and microbial bacterial infections.

KEYWORDS: *Solar, Water Purifier, Drinking Water, Membrane, Arduino UNO*

1. INTRODUCTION

Rapid industrialization and urbanization for fast growing populations, the scarcity of fresh water is becoming a very severe issue in many regions of the world. To address this issue, clean and sanitary water purified from seawater or waste water has provided an alternative resources. At the same time, advanced sustainable technologies and renewable energies need to be considered to mitigate and reduce the burden to the environment. Solar energy is the most earth-abundant and easily accessible among various clean energy sources such as wind, nuclear, tidal, biomass, and geothermal.

Clean water for drinking, household and industrial purposes can be obtained by solar water purification through the usage of solar energy in many different ways. Solar energy application for water treatment has become more common as it is a low cost technology solution that works to capture the light and heat energy from the sun to make water cleaner and healthier for human and industrial use and consumption. For rural communities, as they do not have other forms of water purification systems and more importantly electricity to run such systems, solar water treatment is particularly very beneficial. The most important feature about solar water purification is that there is no requirement of conventional fuel to run this system. Solar energy applications relatively superior than conventional sources of energy as it does not cause pollution or health hazards associated with pollution. There are four main types of solar water treatment: solar water disinfection (SODIS), solar distillation, solar water pasteurization, and solar water treatment systems. Some of these technologies are available for a very long time, but most are new adaptations to the concept of solar energy. These technologies are also very cost effective, simple and easy to understand [1].

For various types of water treatment processes, membrane has a very crucial rule. The conventional water treatment method combined with membrane filtration is used for waste water recovery, while distillation or reverse osmosis membrane filtration is typically utilized for seawater desalination. Among them, a low cost solar interface evaporation technology is used for wastewater treatment and saltwater desalination, to solve the issue of water scarcity in underdeveloped and remote areas. Now-a-days, the functional materials and bio-inspired structure design are used for solar evaporators. Certain common functional materials for the purpose of water purification, including

carbon nanotube [2], graphene [3], polymer [4], hydrogel [5,6] and biochar [7] has been extensively used by the current researcher all over the world.
Most recently, ARDUINO UNO is also used as core controller and various sensors to monitor the quality of water in real time in various solar powered water purification systems. The portable and automatic Arduino based smart water purifier for quality monitoring system saves time and human resources [8,9].

2. LITERATURE REVIEW ON SOLAR WATER PURIFIER DESIGN

Acholkar et al. (2015): They have designed one solar water purifier (Fig-1) to get clean and safe water for human consumption by effective utilization of solar energy by using CSP through cylindrical parabolic trough to rise the temperature above 80°C which is capable to deactivate all classes of pathogens. They have also used a carbon filter to remove sediments and particulate matter [10].

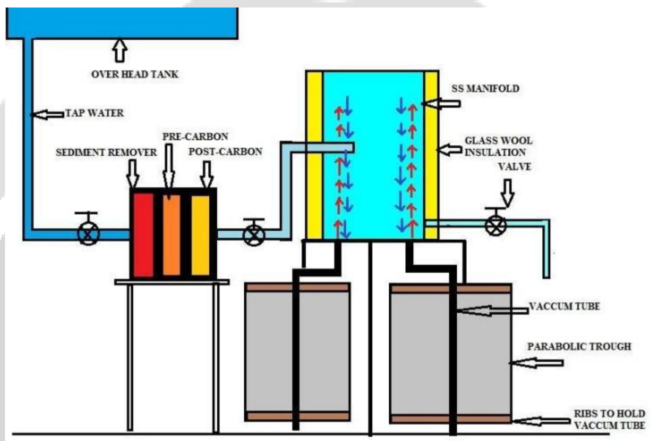

Fig-1: Layout of Solar Water Purifier

Arasu et al. (2019): In this research work, they have proposed a solar powered water purifier (Fig-2) using a cartridge heater to produce clean drinking water in flood affected areas or remote areas where potable water is not easily accessible. Their water purification system is based on distillation technique, with an automatic valve which fills up a tank and heats up the water. The steam produced by this system is captured by a condensation unit and flowed into clean water holding tank. This system is easy to move and install in places where spaces are limited due to its compact size [11].

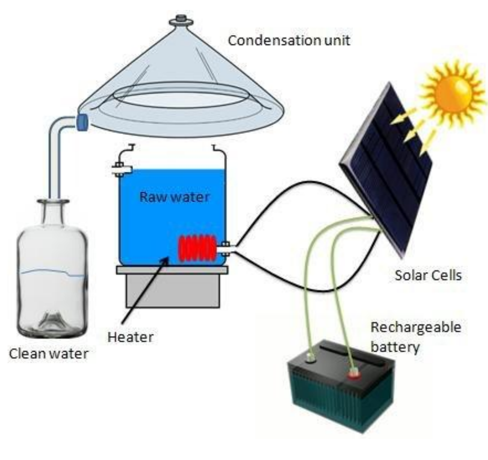

Fig-2: Schematic diagram of a solar powered water purifier

NetSol Water: They have designed a solar powered RO system (Fig-3) which is a new concept in the Indian water purification sector. This solar powered system can produce safe drinking water where ever we need it, whether it's from a river, pond, or bore well. This system is also ideal for military camps, village areas, fairs, and tourist destinations where temporary drinking water is required at a low cost. There are two parts in this solar RO system: one is power generation unit and the other is desalination unit. The RO unit requires a stable power supply, so the system's electricity will be supplied by the solar PV array, and batteries will be linked to provide that power. On the brine side, the RO desalination process are connected with 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. 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 [12].

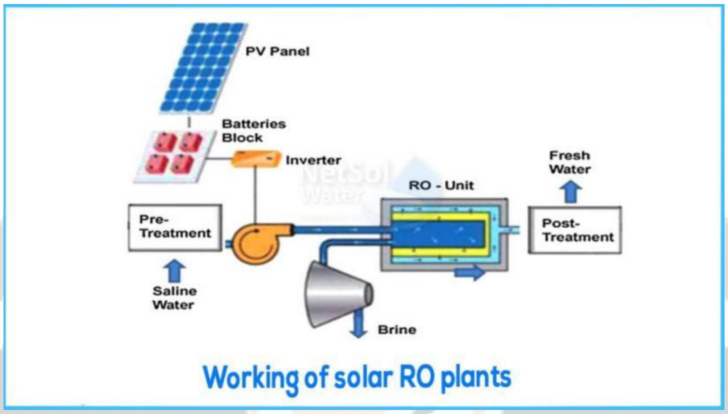

Fig-3: Solar Powered RO system

Anuaksh Solar: They have designed a solar thermal based water purifier (Fig-4), where they have used parabolic reflector to collect the solar energy. They also used evacuated vacuum tube collector consists of two concentric glass tubes to reduce the heat loss by convection to surrounding. In this system, they have also used three layered carbon filters, which are sediment removal, pre-carbon and post-carbon filter. In first part, sediments are removed and then other aesthetics like colour and odour are controlled by pre and post carbon filter. The processing capacity of the filter is 3.7 LPM. The filter can effectively remove sediment particles of size 0.5 to 50 micrometers [13].

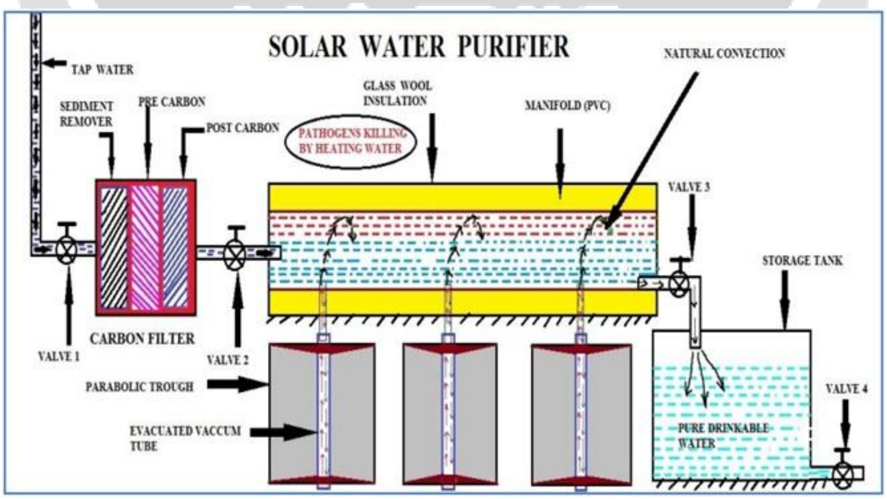

Fig-4: Water Purifier based on solar thermal

NEWater: They have designed a solar water purifier (Fig-5) which is easy to carry and transport, making it highly portable. This system automatically adjusts pressure based on water quality for optimal performances. Multiple stage processes have been used here. RO technology is used to remove contaminants such as organic impurities. After that, deionization processes where resins are used to remove unnecessary mineral ions and post-treatment methods such as UV filtration is used to remove microbial and viral pathogens to ensure that the water is safe, clean and healthy for human consumption [14].

Fig-5: Solar water purifier manufactured by NEWater

3. LITERATURE REVIEW BASED ON MEMBRANES

Han et al. (2019): They have designed and fabricated a series of ultrathin porous membrane (Fig-6) derived from the eggshell membrane bio-wastes. The as-prepared carbonized eggshell membrane possessed a homogeneous porous micro-structure with an average pore size ranging from a few microns to several tens of microns and uniform thickness of ∼15 μm, enabling great capabilities for efficient water/vapor transportation and localized heating by solar driven water treatment. The bio-generation cycle they designed here combines recycling from domestic waste, utilization of renewable solar energy, and production of clean water, making it truly a low-cost and environment-friendly solution to global water scarcity [2].

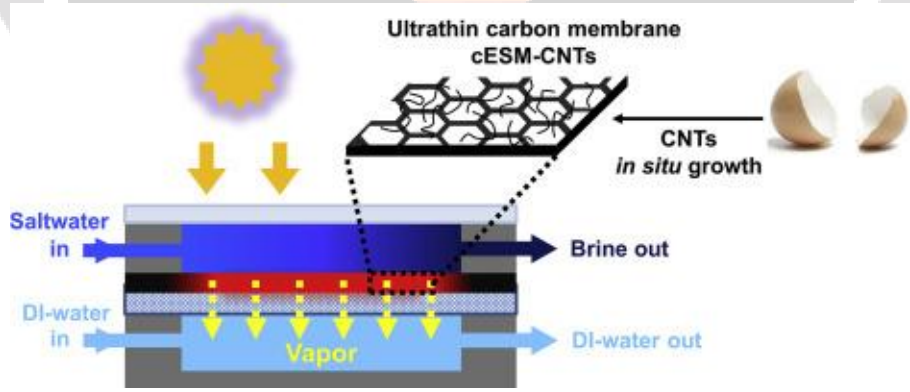

Fig-6: Ultrathin porous membrane derived from the eggshel

Dai et al. (2022): In this review work, they have shown that graphene-based membranes (Fig-7) have unique nanochannels and can offer advantageous properties for the water desalination process [3].

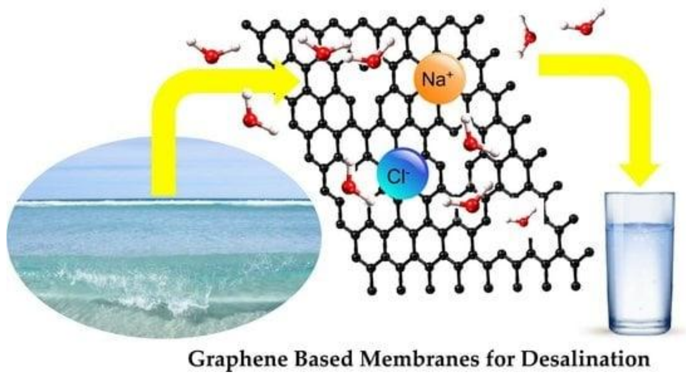

Fig-7: Graphene Based Membranes for Desalination

Xu et al. (2022): In this article they have shown that cost effective polymer based membrane (Fig-8) filtration is a broadly used technique in water purification. In this review, the basic structures of polymer-based water purification membranes including the effective layer for separation, the support layer and the possible top protective layer are presented. Details include the conventional membranes for microfiltration (MF) and ultrafiltration (UF), the effective layers for separation in thin-film composite (TFC) membranes, electrospun nanofibrous membranes for MF, UF, and membrane distillation (MD), as well as the emerging self-assembled block_copolymer membranes. Furthermore, the conventional support layers and electrospun nanofibrous support layers for reverse osmosis (RO) and forward osmosis (FO) processes, and the top protective layers are discussed. The materials, membrane structures and properties, modification strategies, possible interlayers, interconnects, interpenetration, and interactions between different layers are also discussed, with the emphasis on the cost-effectiveness of various membranes [4].

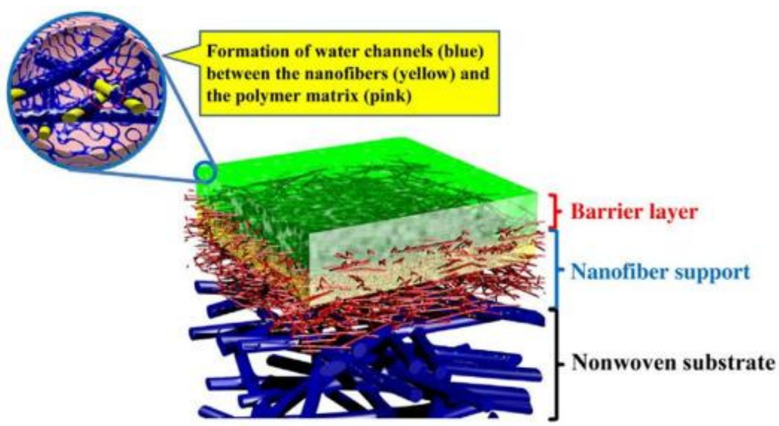

Fig-8: Polymer based membrane

Wang et al. (2022): Here, they present a carbonized cattail–agarose hydrogel (CCAH) membrane (Fig-9) with numerous microchannels resembling bamboo knots, exceptional hydrophilicity, outstanding light absorption capability, and potent adsorption. Under one solar irradiation, its evaporation rate and efficiency reached 1.93 kg $m^{-2}h^{-1}$ and 95.8%, respectively. More importantly, the CCAH membrane produces steam water that is almost totally free of salts (Na^+, K^+, Mg^{2+}, and Ca^{2+}), heavy metal ions (Pb^{2+}, Cd^{2+}, and Cr^{2+}), and organic dyes (Rhodamine B, methylene blue, and methyl orange). The CCAH membrane is highly promising for the use of saltwater desalination and wastewater recovery to help people in impoverished areas with water scarcity problems [5].

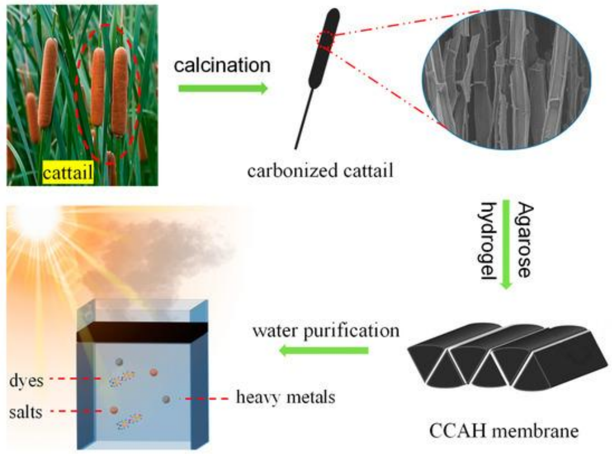

Fig-9: Schematic diagram of preparation process and application of carbonized cattail–agarose hydrogel (CCAH) composite membrane for solar water evaporation and water purification.

Zhang et al. (2023): Here, they report a porous hydrogel membrane (Fe/TA-TPAM) (Fig-10) for the purification of high ion concentration and contaminated water. The hydrogel membrane exhibits good light absorption and photothermal conversion ability, which shows high evaporation rates (1.4 $kgm^{-2}h^{-1}$) and high solar efficiency for seawater. Furthermore, with the introduction of tannic acid (TA) and Ti_3C_2 MXenes, the Fe/TA-TPAM hydrogel membrane exhibits satisfied purification properties for organic-contaminated and biologically contaminated water. The excellent purification effect of Fe/TA-TPAM under light not only confirms the rationality of the hydrogel porous design and in situ generation of photosensitizer in improving the photothermal performance but also provides a novel strategy for designing advanced photothermal conversion membranes for water purification [6].

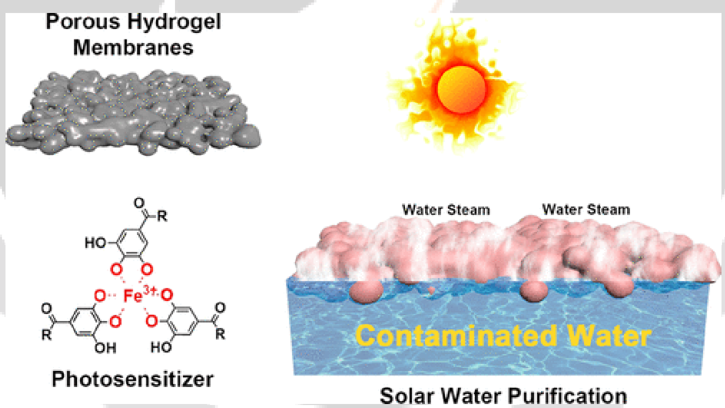

Fig-10: Porous hydrogel membrane (Fe/TA-TPAM)

Wang et al. (2023): In this work, a silver nanoparticle (AgNP)@carbonized cattail/polyvinyl alcohol composite hydrogel (ACPH) membrane (Fig-11) is developed as a solar interface evaporator for seawater desalination and wastewater treatment. More importantly, the membrane exhibits superior purification ability in a variety of sewage. Pollutant removal rates in heavy metal and organic dye sewage have exceeded 99.8%. As a result, the ACPH membrane holds great promise for wastewater recovery and seawater desalination, which can aid in resolving the water crisis issue [7].

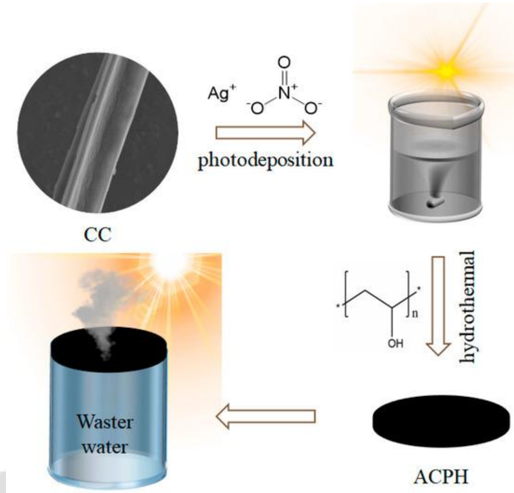

Fig-11: Silver nanoparticle based ACPH membrane

Cui et al. (2024): Solar-driven interfacial water evaporation shows great potential to address the global water crisis, but its efficient implementation in the presence of organic wastewater remains challenging. Here, they achieved integrated water evaporation and organic compound degradation by designing a multifunctional MoS_2 membrane (Fig-12). Under 1.0 sun irradiation, the membrane exhibits an evaporation rate of 2.07 $kgm^{-2}h^{-1}$ and 82% degradation efficiency of organic pollutants, with negligible organic pollutant residues in the condensate. The high performance is attributed to the thermal energy generated by the evaporation process of MoS_2 membrane. This promotes an increase in the rate constant of interfacial electron transfer during the photocatalytic reaction, accelerating the generation of free radicals and facilitating the removal of organic pollutants. Their study also demonstrated that fresh water can be collected from high-salinity wastewater at a rate of 1.56 $kgm^{-2}h^{-1}$. The MoS_2 membrane provides a sustainable approach to addressing the water crisis [15].

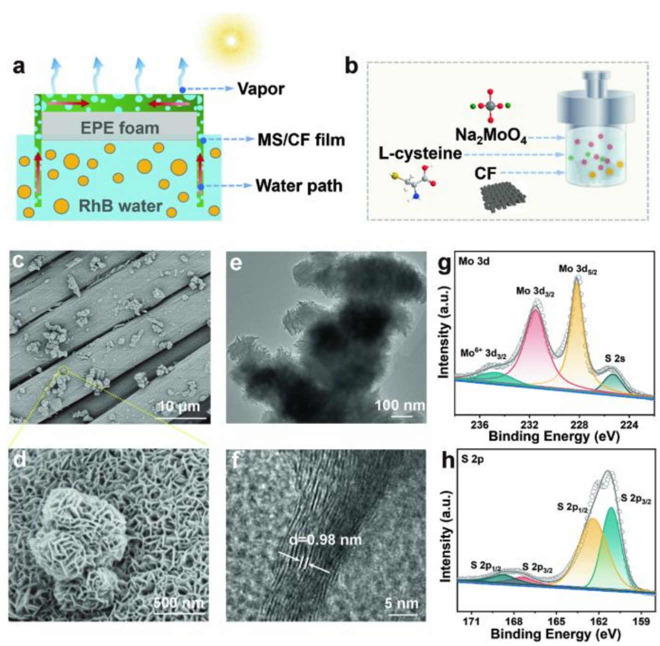

Fig-12: MoS_2 membrane

4. LITERATURE REVIEW BASED ON ARDUINO UNO

Very few works has also been done by using Arduino UNO to get portable and automated solar powered water purifier for human and industrial utilizations.

Banu et al. (2021): In their solar powered filtration system (Fig-13), they have designed a simple but effective water purifying system to provide the purified water to all at a very low consumption of energy. The energy from the solar panel stored in battery is used for purification of water. The main purpose of Arduino UNO in this system is to control the flow of water in the tank, to check the battery condition and indicates the signal to the LCD and relay. The LED indicates the level of water filled in the tank and also it indicates the running of motor [8].

Fig-13: Arduino based solar water purifier

Mahendhiran et al. (2022): They have designed a Arduino UNO based smart water purifier (Fig-14), a real time system for assessment of fully automated portable water quality for human consumption. Their system consists of different type of sensors, notification module with LCD display, WI-FI along with Arduino. This portable and automatic water quality monitoring and notification system saves time and human resources. Different sensors are connected to Arduino to monitor the conditions of water. The Arduino will access the data from different sensors and then processes the data. The sensor data can be viewed on the LCD and cloud [9].

Fig-14:Arduino UNO circuit

5. CONCLUSIONS

From this complete literature review, it is found that numerous methods are developed for purification of water. Among them, solar powered water purification system has great potential to overcome this water crisis in developing and under developing nations due to low operating cost. Saline water and waste water recovery is also possible by using different membranes based solar water purification methods and whole system can be automated by using Arduino UNO to get real time data.

6. REFERENCES

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