

Design and Fabrication of a Portable Solar Powered Water Purification System

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Abstract

Access to clean and safe drinking water is vital for human well-being, yet a significant portion of the global population lacks access to clean water sources. Traditional water purification methods often require large-scale infrastructure and also consume fossil fuels, thereby contributing to environmental degradation and exacerbation of resource scarcity. To address these challenges, this paper proposes a portable solar-powered water purification system that harnesses renewable energy to provide sustainable and reliable access to clean drinking water. The innovative system integrates solar energy capture, advanced filtration techniques, and effective disinfection mechanisms. After the fabrication of the frame with a mild steel, the design revealed that the power required to drive the pump is 5.42kWatts. The filtration stage employs a multi-layered system comprising activated carbon filters, reverse osmosis membranes, and ceramic filters, ensuring the removal of pollutants, contaminants, microorganisms, and even microscopic particles. Additionally, the system incorporates an Ultraviolet (UV) purification module, which utilizes UV-C radiation to eradicate harmful pathogens, bacteria, and viruses, including waterborne diseases such as cholera and typhoid. With its sustainable energy source, compact design, and robust purification capabilities, this system has the potential to revolutionize emergency response efforts in remote areas without infrastructure, or in regions affected by natural disasters. The portable solar-powered water purification system represents a promising solution to addressing the global water crisis, and also reduces over reliance on non-renewable energy sources.

Keywords: water purification, solar power, portable system, renewable energy, design, fabrication

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I. Introduction

Access to safe and clean drinking water remains a significant challenge in many parts of the world, particularly in remote areas and regions affected by natural disasters or humanitarian crises. Contaminated water sources contribute to the spread of waterborne diseases, posing serious health risks to communities. Traditional water treatment facilities are often impractical or unavailable in such circumstances, necessitating the development of alternative solutions. Water is one of the most essential resources on the planet, and access to clean and safe drinking water is crucial for the well-being and survival of all living organisms. However, due to various environmental factors and human activities, water sources often become contaminated with harmful substances, pathogens, and pollutants. This contamination poses serious health risks and can lead to water borne diseases.

To combat this problem, water purification processes are employed to remove impurities and make water safe for consumption. These processes involve a series of physical and chemical methods that effectively eliminate contaminants and also ensure the delivery of clean and potable water. By understanding the water purification process, insights were gained into the vital role it plays in safeguarding public health and promoting sustainable development. With the increasing global population and growing environmental concerns, the need for efficient and reliable water purification techniques has become more critical than ever.

Understanding the various sources of water is crucial to ensure its sustainable use, management and best means of purification. Water can be obtained from various sources which include: surface water, ground water, precipitation, springs, glaciers and ice caps, desalination, as well as recycled water. This project is centered on the purification of surface water from rivers, streams, wells, etc.

Surface water are generally known to have impurities such as dust, fine sand, clay, dirt, and biological contaminants. Some of them are known to harbor unfavorable chemicals and elements which include acid and metallic rust element. Without purification, this water could lead to several ailments like cholera, dysentery,

typhoid, guinea worm, etc. In other case, it could lead to scaling and corrosion of metals. Micro-organisms like bacteria, algae, and fungi can also interfere with sterile research applications in surface water.

Defined as the process of removing undesirable chemicals, biological contaminants, suspended solids, and gases from water to make it safe for consumption or other uses, water purification involves various techniques and methods to eliminate impurities and ensure water quality. Different methods have been used by several generations in the past. Although some are very archaic, it has over time been modernized and been used to purify other liquids as well. Some common purification processes include distillation, de-ionization, filtration, and the addition of chemicals to remove particles and contaminants. Portable water purification systems powered by renewable energy sources offer a promising approach to address this pressing issue, ensure the availability of safe and clean drinking water which will directly protect public health, preserve the environment, and also support various industries and agricultural activities.

II. Literature Review

Contaminated Water

Aquaporin (2022), defined contaminated water as any water that contains harmful chemical, biological, physical, radiological substances, or matter which pose a threat to human health. Contamination can occur due to the presence of pollutants such as heavy metals, pathogens, pesticides, or industrial chemicals beyond permissible limits. According to the World Health Organisation (2023), safe and readily available water is very crucial for public health, whether it is used for drinking, domestic use, food production or recreational purposes. It observed that improved water supply and sanitation, and better management of water resources, can enhance countries' economic growth and can also contribute greatly to poverty reduction.

Contamination can occur through various sources and pathways, including natural processes, human activities, industrial processes, and environmental factors, and can be caused by factors like industrial runoff, agricultural activities, municipal waste discharge, or natural geological processes. Lin, Yang, and Xu (2022), explained that water pollution is caused by various factors, including both natural processes and human activities. they listed the following as the causes of water pollution: industrial discharge, the use of fertilizers, pesticides, and herbicides in agricultural practices can result in the runoff of these chemicals into nearby water sources, sewage and wastewater from households, commercial establishments, and urban areas contain pollutants such as pathogens, nutrients, and chemicals, and if not properly treated, these contaminants can enter rivers, lakes, and underground water sources, thereby posing risks to aquatic life and public health, as well as oil spills.

According to Denshak (2023), water pollution occurs when harmful substances usually chemicals or microorganisms—contaminate a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment. She disclosed that this widespread problem of water pollution is jeopardizing peoples' health, as unsafe water kills more people each year than war and all other forms of violence combined.

Water Purification

Enzler (2018), observed that the ancient Greek and Sanskrit writings dating back to 2000 BC, recommended water treatment methods, as people back then knew that heating water might purify it, and they were also educated in sand and gravel filtration, boiling, and straining. These civilizations developed various methods to purify water, often using natural materials and techniques. According to the International Water Association (2023), the Greeks and Romans adopted diverse methods to enhance the quality of the water if it did not satisfy their quality requirements, such as settling tanks, sieves, filters and the boiling of water. However, it noted that although the boiling of water might have been feasible from a hygienic point of view, it was ecologically and economically not feasible in extensive use since firewood and other combustibles would sooner or later have become a scarce resource around the Mediterranean.

In the 17th century, water treatment plants began to emerge in Europe, utilizing sand filtration and adding chemicals like alum to remove impurities. According to Watters (2017), although there were mentions of boiling water and filtering through gravel and sand dating back to prehistoric times, it was not until the early 19th century that towns were being supplied with water run through a filter. She disclosed that Paisley, Scotland became the first city to use a filter to supply an entire municipality with water. Innovations such as rapid sand filtration, disinfection using chlorine, and the use of activated carbon for removing organic compounds revolutionized water treatment processes. These advancements significantly improved the quality of drinking water and helped to combat waterborne diseases.

Overall, the origin of water purification systems can be attributed to the collective efforts of ancient civilizations and the continuous advancements in scientific knowledge and technology over time. Today, WPS continue to evolve, with a focus on sustainability, energy efficiency, and the removal of emerging contaminants.

Advanced technologies, such as membrane filtration, advanced oxidation processes, and solar-powered systems, are being developed to address the growing challenges of water scarcity and pollution.

Pureitwater (2023), explained that there are different methods of water purification, each with its own merits and demerits. While pointing out that the method one chooses is dependent on the need and the type of contaminants, it opined that boiling, filtration, distillation, chlorination, ultra violet treatment, and reverse osmosis are some of the most familiar methods of water purification. Water purification is indispensable for public health, environmental protection, and sustainable development, as ensuring access to safe and clean water, purification technologies contribute significantly to improving quality of life and fostering a healthier and more resilient society.

Portable Solar-Powered Water Purification System (SPWPS)

According to Khan et al. (2015), simple solar system helps to remove turbidity as well as chemical and pathogenic contaminants from water sources in the most affordable, and expedient manner possible. Solar-powered water purification systems use solar energy to power various purification methods, such as filtration, disinfection, or desalination. They are particularly suitable for remote or off-grid areas with limited access to electricity. Aziz et al. (2023), observed that solar water purification entails the refinement of water for potable and domestic use by harnessing solar energy in a diversified array of methodologies. They explained that the utilization of solar energy in water treatment has gained prevalence due to its inherent attributes as a typically uncomplicated and low-tech solution that harnesses solar heat and energy to render water safer and more salubrious for human consumption.

Description of a SPWPS

Rank (2020), defined a SPWPS as a portable water purification system that cleans water through solar energy in order to remove contaminants such as bacteria, viruses, and protozoa. He explained that it does so through a mixture of electricity generated by solar PV panels, solar heating, or solar ultraviolet light collection. Access to clean water through purification systems is vital for preventing illnesses and promoting good health.

According to Dikgale et al. (2020), The design of solar-powered water purification systems is regarded as an important means of producing clean water, because solar energy poses no polluting effect and has become a dependable energy source for usage. The system offers a practical and sustainable approach to addressing water scarcity and contamination challenges, by leveraging solar energy to produce clean water. The system contributes immensely to improving health outcomes, enhancing resilience, and promoting environmental stewardship in communities.

The system is equipped with a solar panel mounted on its top. The solar panels capture sunlight and convert it into electricity through photovoltaic cells. The size and capacity of the solar panel determine the system's power generation capabilities and its ability to operate efficiently in various lighting conditions. To ensure continuous operation, the system includes a battery storage unit to store excess solar energy generated during the day.

These batteries are typically rechargeable and store energy for use during periods of low sunlight or at night. The battery capacity is designed to provide uninterrupted power to the water purification system, even in low-light conditions. The system is equipped with an intake mechanism to draw water from a water source, such as a river, lake, or well. Before purification, the water will undergo pre-treatment to remove larger debris, sediment, and other visible contaminants through processes such as screening or settling.

The purified water is collected in a storage tank or container within the system, ready for distribution and consumption. The systems also include a dispensing mechanism, such as a tap, for convenient access to clean water. SPWPS are designed to be lightweight, compact, and rugged for easy transportation and deployment in remote or off-grid locations. These systems feature durable housing materials, reinforced components, and ergonomic handles for enhanced portability and durability. Advanced systems may include monitoring sensors and control systems to track water quality parameters, system performance, and energy usage. Users can monitor key metrics such as water flow rate, solar energy production, battery status, and purification effectiveness to ensure optimal operation and maintenance of the system.

III. Methodology

The general requirements of the user, the water source and purification technique should be considered in the solar powered water purification system. To design a system that is effective, secure, and simple to operate, a number of factors including power, pump speed, purification type and size of the system, purification capacity, safety features, ergonomics, durability, and maintenance were carefully considered. To minimize accidents, the WPS should be designed with safety features such as an emergency stop switch, and other safety mechanisms.

The ergonomics of the operator should also be considered during the design of the water purification system. To minimize user fatigue, the handle and weight of the system should be balanced and easy to hold or transport. The materials and components used in the WPS should be of the highest quality and should be built to have a long duration of service life with replaceable parts and easily available components for cleaning.

Principle of Operation

The working principle of the SPWPS is based on the conversion of solar energy into electrical energy with the help of a solar panel, inverter and a battery which powers the different individual components of the system.

The system typically consists of four main components: a solar panel, a water pump, a water treatment unit, and a storage tank. The principle of operation of the SPWPS is depicted in figure 1.

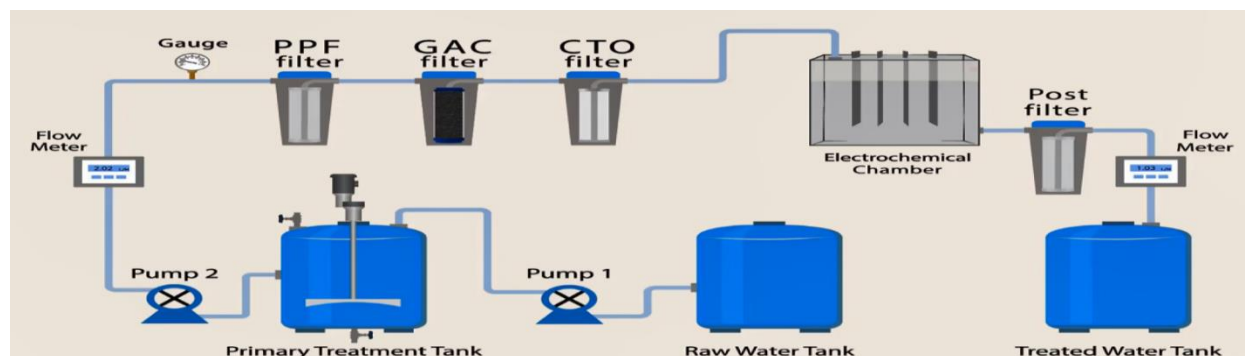


Fig. 1: Principle of operation of the water purification system.

Design Analysis

The frame (chassis), solar panels, water pump, pipes, water filters, UV canister, flocculation rod, storage tank are the common primary parts of an SPWPS. The frame, which offers stability and support, is the system's basis. The components mount the frame, which acts as the framework for housing the other parts. The pump which is usually an electric rotor when powered pulls the water from the source to other components through valves by increasing the pressure of the water, which is positioned on the frame.

When designing a solar-powered portable water purification system, several key considerations were made to ensure its efficiency, reliability, and usability. Here are some important design considerations:

Solar Panel Efficiency: The solar panels used in the system were selected for their efficiency in converting sunlight into electricity. This is because high-efficiency solar panels will maximize the power output and minimize the size and weight of the system.

Water Treatment Technology: The selection of water treatment technology was based on the specific contaminants and water sources that the system will encounter. The system incorporated multiple treatment methods such as filtration, disinfection, or desalination to address different water quality issues.

Compact and Lightweight Design: Portability is a crucial aspect of a portable water purification system. The system was designed to be compact, lightweight, and easy to transport. Considerations were also given to the size and weight of the individual components, as well as the overall design and packaging of the system.

Durable Construction: Since portable systems may be used in rugged environments or during emergencies, the system was designed with durability in mind. Robust construction and the use of durable materials will ensure that the system can withstand physical impacts, vibrations, and harsh environmental conditions.

User-Friendly Interface: The system has a user-friendly interface that is easy to understand and operate. Clear instructions, intuitive controls, and visual indicators can help users effectively use and maintain the system without extensive technical knowledge.

Water Storage and Dispensing: The system included provisions for water storage and convenient dispensing. This involved the incorporation of water storage tanks or containers with hygienic features and designed easy-to-use dispensing mechanisms such as taps, spigots, and pumps.

Maintenance and Servicing: Design considerations was also given to facilitate maintenance and servicing of the system. Easy access to components that will require cleaning, replacement, or repair can minimize downtime, and ensure the long-term reliability of the system.

Safety Features: The system was designed to incorporate safety features to ensure the quality and safety of the purified water. This included pre-filters to remove larger particles, indicators to monitor water quality, automatic

shut-off mechanisms when water quality standards are not met, and fail-safe measures to prevent system malfunctions.

Design Calculations

Frame

Designing and analyzing a chassis frame is a critical aspect of vehicle engineering. The chassis frame provides structural support and integrity to the vehicle, ensuring that it can withstand various loads and stresses during operation. To calculate the reciprocating unbalanced inertia force in a water storage system with a reciprocating pump or other reciprocating machinery, the following formula was applied:

$$F = m \cdot (L \cdot (\omega^2) \cdot \sin(\theta)) \quad (3)$$

where: F is the reciprocating unbalanced inertia force, M is the mass being moved (in this case, the mass of water being pumped), L is the stroke length of the reciprocating motion (distance traveled by the pump or piston), Ω is the angular velocity of the reciprocating motion, and θ is the angle between the connecting rod and the line of stroke.

Spring force: $F = \text{spring constant} \times \text{Depth or Height}$

Net vertical force: $F_y = [\frac{1}{2} M_{\text{rec}} + M_{\text{rot}}] \omega^2 r \cos(\omega t)$

Net horizontal force: $F_x = [M_{\text{rot}} - \frac{1}{2} M_{\text{rec}}] \omega^2 r \sin(\omega t)$

A chassis frame can be looked upon as a 3-D space frame of beam and rod elements. Beam elements of different cross sections were used to model the load carrying members of the frame.

Shear Force, Bending Moment and Strength of the Structure

During the stationary position, a horizontal load acts on the platform. This load acts in addition to the load in stationary condition. So for this case, the resultant bending moment is the combination of horizontal and vertical bending moment. The maximum Reaction Force at the fixed end can be expressed as:

$$R_A = F \quad (3a)$$

Where: R_A = reaction force in A (N, lb.), F = single acting force in B (N, lb.)

Maximum Moment

At the fixed end can be expressed as:

$$M_{\text{max}} = MA = -FL \quad (3b)$$

Where: MA = maximum moment in A (Nm, Nmm, lb. in), L = length of beam (m, mm, in),

Maximum Deflection

At the end, the cantilever beam can be addressed as:

$$\delta_B = FL^3 / (3EI) \quad (3c)$$

Where: δ_B = maximum deflection in B (m, mm, in), E = modulus of elasticity (N/m² (Pa), N/mm², lb./in² (psi)),

I = moment of Inertia (m⁴, mm⁴, in⁴), b = length between B and C (m, mm, in)

Stress

The stress in a bending beam can be expressed as: $\sigma = yM / I$ (3d)

Where: σ = stress (Pa (N/m²), N/mm², psi), y = distance to point from neutral axis (m, mm, in), M = bending moment (Nm, lb. in), I = moment of Inertia (m⁴, mm⁴, in⁴).

The maximum moment in a cantilever beam is at the fixed point and the maximum stress can be calculated by combining 1b and 1d to $\sigma_{\text{max}} = y_{\text{max}} FL / I$ (3e)

During stationary position, a horizontal force of magnitude is equal to half of vertical loads magnitude at respective load distribution locations. This is taken into account by considering a moment around the centroid axis of the outer longitudinal member.

Stresses in the Longitudinal Member

The resultant bending moment is the vector sum of the maximum bending moments at the mid load distribution location. So the resultant bending moment is given as:

$$M = \sqrt{(53.6)^2 + (60)^2}$$

$$M = 80.45470776 \text{KN-m}$$

Using this value of bending moment we further compute stress using the fundamental bending equation as: $f = \frac{M}{z}$ (3f)

Inputting the values of maximum bending moment and section modulus computed in (3f), the stress magnitude at stopping can be gotten.

$$F \text{ (stationary position)} = \frac{80.45470776}{965241.9618}$$

$$F \text{ (stationary position)} = 125.425\text{MPa}$$

Power Calculation

Power is calculated as: Power = pressure * diameter of pipe (meter/min)/ volume

where, Pressure = pipe length * pressure per minutes / 1000,

Using the following parameters:

Pipe length = 10 to 12inches (254mm to 305.8mm) for a regular pipe length, Flow per minute= 150 to 300mins

Pressure = 254 * 150/1000 = 38.1m/min

Assuming the efficiency of the pump ranges from 75% to 78% and water pressure = 10668N

∴ Power= pressure * diameter of pipe/ volume = 10668 * 38.1/75 = 5419.344Watts

The power required to drive the pump = 5.42kWatts

Material Selection

The choice of materials is essential in engineering design, since it has a direct impact on the functionality, dependability, and durability of the final product. The chassis frame is depicted in figure 2.

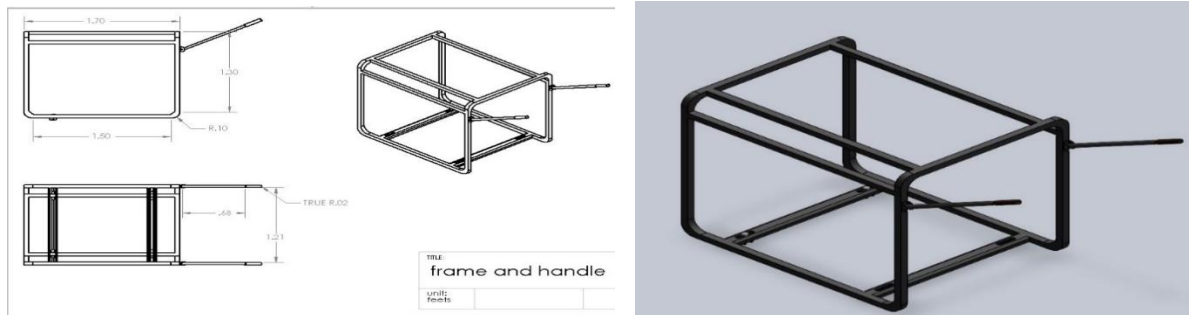


Fig. 2: Chassis frame (front, bottom and isometric)

Storage System

Water storage design and analysis involves determining the appropriate size, shape, and materials for effective water storage. The storage unit is shown in figure 3.

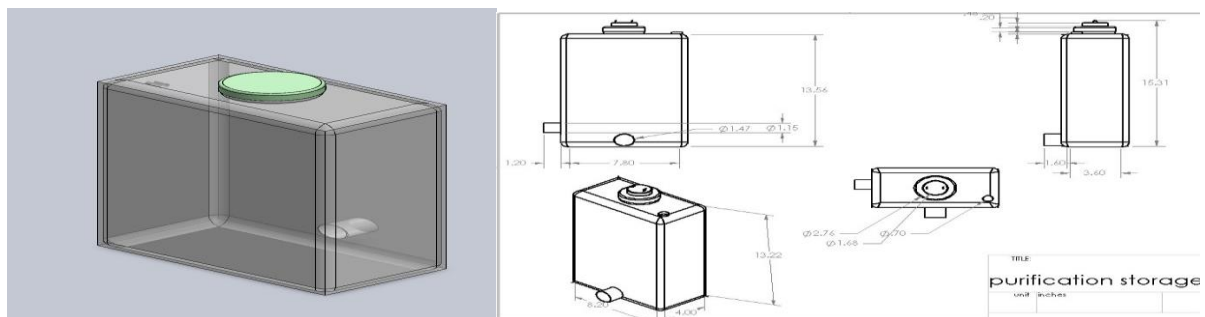


Fig. 3: storage unit (front, bottom and isometric) with SW

The Pump

Pumps are mechanical devices used to move fluids from one place to another by increasing the pressure of the fluid. The selected pump is depicted in figure 4.

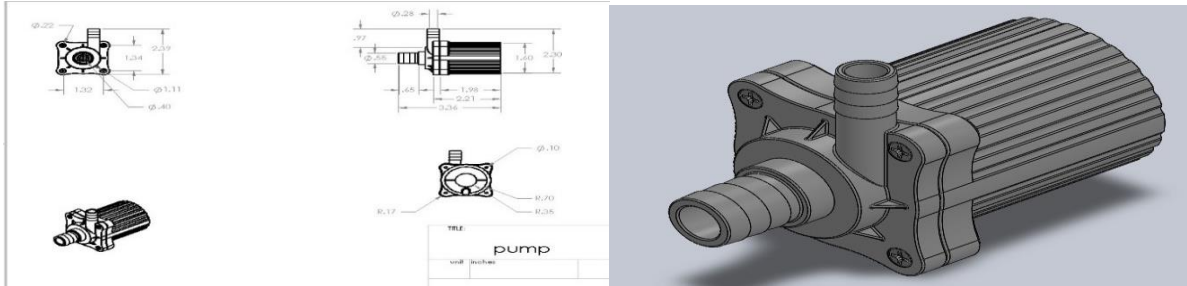


Fig 4: Pump (front, bottom and isometric)

The Filter

Water filters are devices that are used to purify and remove impurities from water, making it safe for consumption or other purposes. They are designed to remove contaminants such as sediments, bacteria, viruses, chemicals, and odors, improving the taste and quality of the water. The selected filter for the SPWPS is depicted in figure 5.

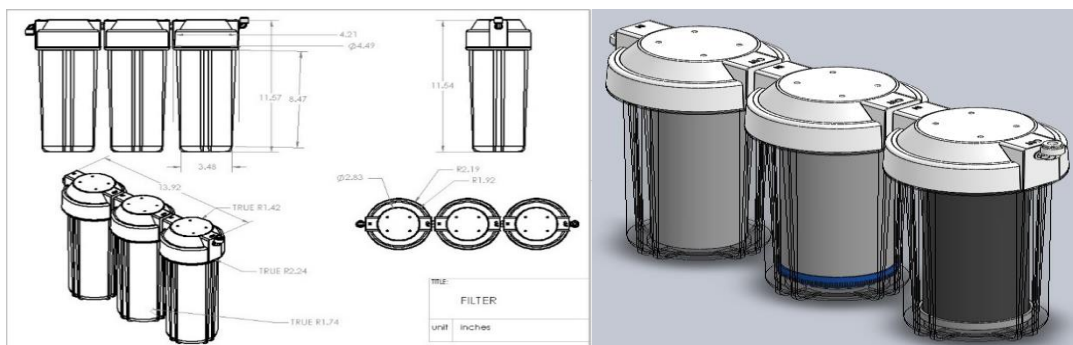


Fig 5: Filter (front, bottom and isometric)

UV CANISTER

UV (Ultraviolet) as shown in figure 6 filters use ultraviolet light to kill or deactivate bacteria, viruses, and other microorganisms in the water. They are typically used in combination with other filtration methods to provide complete purification.

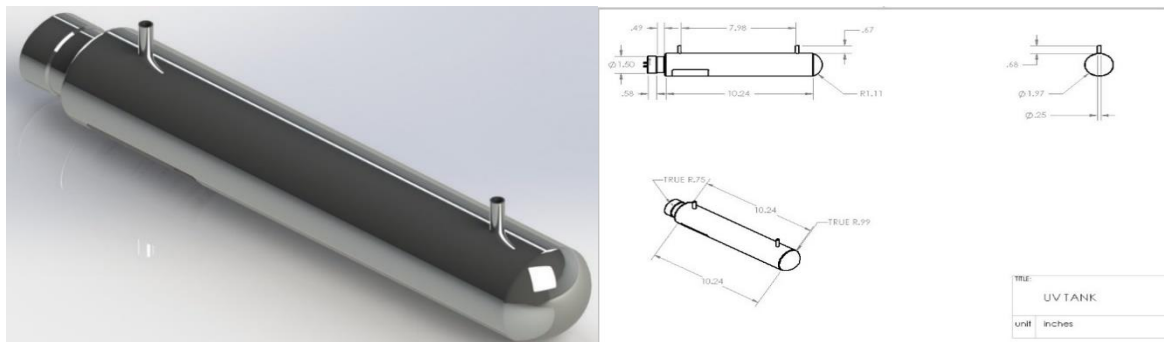


Fig 6: UV canister (front, bottom and isometric)

SOLAR PANEL

Solar panels as depicted in figure 7 are devices that collect and convert thermal energy from the sun into electrical energy.

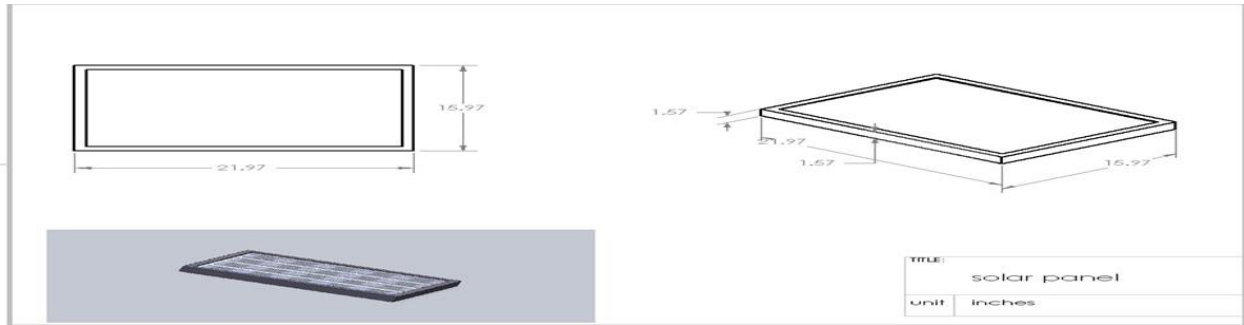


Fig. 7: solar panel (front, bottom and isometric)

The exploded view of the SPWPS is shown in figure 8.

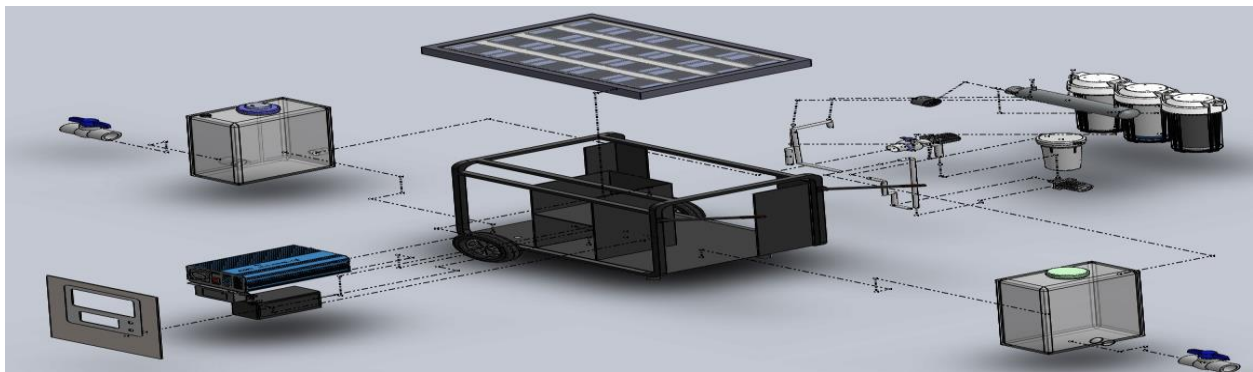


Fig. 8: Exploded view of the SPWPS

The various components, materials, and specifications of the SPWPS are depicted in table 1.

Table 1: Parts and components

S/N	Parts/Components	Material	Specification
1	Frame	Mild Steel	2 inches by 1 inch
2	Solar panel	Aluminum	20mm
3	Filters	PET plastic	5mm
4	pipes	PVC	5mm
5	Uv canister	Stainless steel	4mm
6	Pump	Plastic	12V to 24V
7	Inverter	Ductile Iron	1000kw
8	Battery		12V
9	Storage unit	Plastic	10mm
10	Control valves	Thermoplastic	1.5inches

IV. Methodology

The main operations applied in the fabrication process of the SPWPS are as follows:

Cutting operation: Cutting operation was performed on a mild steel metal sheet according to the required dimensions to fabricate the frame. Eight mild steel rods were cut according to the required dimensions to fabricate the standing structure of the chassis. Cutting operation was also carried out during the fabrication of the frame handle.

Drilling operation: This operation was performed to make holes on the frame in order to create coupling spaces. Drilling operation was also performed on the panel cover.

Welding operation: Arc welding was performed at various places where permanent joints are required. The chassis (frame) was joined by arc welding. While fastener were used where temporary joints were required.

Fabrication Procedure: Firstly, in the construction of the frame of the system, 2-inches by 1-inch mild steel was cut using the required dimensions of length - 22inches, before it was welded together, while the frame was

covered with a thick 2mm mild steel sheet by coupling in order to form the base of the system where the storages, pump, battery, inverter and the UV canister were mounted.

For the construction of the storage, 8mm of PET plastic was coupled to the base of the frame, where both storage units were mounted opposite each other, a coupling space for the placement of the four filters were constructed and joined together by a 1.5-inches coupler ring joint. The pump was held down with the use of bolts and nuts, right next to the first storage unit which is the purification storage. The pump was connected to the storage using a 1.5-inches of plumbing pipe with a control valve in-between them, the second pump were placed right after the last fourth filter, and connected with a pipe to the clean water storage system. The primary storage unit was constructed to house a flocculation rod, with the length of 5mm and a motor of 5v attached to one end of the rod and a mixing handle on the other end of the rod.

The frame top was designed to hold the solar panel firmly in place with the use of fasteners, while the UV canister was placed right on top of the filters, with the filter acting as a support to the UV canister. The inverter and battery are located and attached to the base of the frame with fastening screws, and the wires held together with the aid of wire clips, after which they were all covered with a panel.

Mode of Operation

The system typically consists of four main components: A solar panel, a water pump, a water treatment unit, and a storage tank. The breakdown of the working principle is given as:

- i. Solar panels: The solar panels were made up of photovoltaic cells that convert sunlight into electricity. They generate Direct Current (DC) electricity when exposed to sunlight, which powers the pumps and UV lamp in the system.
 - ii. Water pump: The DC electricity generated by the solar panels powers a water pump. The pump draws water from a source, such as a well or a river, and directs it towards the water treatment unit. The pump provides the necessary pressure to move the water through the purification process.
 - iii. Water treatment unit: The water treatment unit is the heart of the system and consists of a purification technology.
 - iv. Treatment tank: This is the first treatment phase, when the raw water is collected from the water source, it is allowed to settle for some time, allowing larger particles to settle at the bottom of the tank, and then a coagulant - Aluminum Sulphate is added to the tank, and stirred lightly to evenly distribute the compound, which allow for the thin and lighter dirt to pair together enabling gravity to act on them by settling to the bottom of the tank.
 - v. Filtration: The contaminated water passes through a series of filters designed to remove impurities such as sediments, debris, and larger particles.
 - vi. Polypropylene Fiber (PPF) filter: this is like a honey comb, and removes the sands, silks, and dirt and dust particles.
 - vii. Granular Activated Carbon (GAC) filter: is made from raw organic materials, such as coconut shells or coal that are high in carbon. This filter removes chemicals that are dissolved in water like chlorine, and hydrogen supplied.
 - viii. Chlorine Taste and Odor (CTO) filter: there are varieties of raw materials used to make a CTO filter, most common materials are ambitious coals, wood and nut shells. It removes the cloudiness, bad taste and odour from water.
 - ix. Disinfection: To eliminate harmful micro-organisms, the water may undergo disinfection. This can be achieved through various methods, including ultraviolet (UV) treatment. UV treatment exposes the water to UV light, which destroys the DNA of bacteria, viruses, and other pathogens.
 - x. POST filter: After the disinfection phase by the UV rays, the post filter separates, remove the dead bacteria from the drinkable water, which is then passed to the storage tank.
- iv. Storage tank: Once the water has been treated, it is collected in a storage tank for later use. The storage tank allows for the accumulation of purified water, ensuring a continuous supply even when sunlight is not available, such as during cloudy days or at night. This sustainable and environmentally friendly approach provides access to clean drinking water in areas with limited or no access to electricity or reliable water infrastructure.

V. Conclusion

A solar-powered water purification system offers a sustainable and decentralized approach to addressing the global challenge of access to clean drinking water. The integration of solar energy harvesting technology with water purification techniques provided an environmentally friendly solution that can be deployed in remote or off-grid locations. The design and fabrication of the system required careful consideration of various factors, including system efficiency, reliability, and cost-effectiveness. Continued research and innovation in this field are essential to further improve the performance and accessibility of solar-powered water purification systems. Taking ergonomic suitability of the operator into consideration, the design and fabrication

of the system not only addresses the need for clean water, but also ensures that the operators comfort is guaranteed.

The designed and fabricated solar-powered water purification system offers a sustainable, cost-effective, and reliable solution in addressing water scarcity and contamination challenges. By harnessing the power of the sun, the system provides access to clean drinking water, promoting public health, environmental sustainability, and socio-economic development. Embracing this technology can play a significant role in achieving global water security and improving the quality of life for millions of people worldwide.

References

- [1]. Aquaporin (2022), "Four Types of Contaminants that can be Found in Drinking Water" [Online]. Accessed on 2 April 2024, from <https://aquaporin.com/contaminants-drinking-water/>
- [2]. Aziz, A., Shah, S., Hussain, A., Alam, S., Islam, M. and Rehman, M. (2023), "Solar-Driven Advancements for Water Purification: Harnessing Sustainable Energy for Potable Water Provisioning" *Journal of Xi'an Shiyu University, Natural Science Edition*, vol. 19, iss. 8
- [3]. Denshak, M. (2023), "Water Pollution: Everything You Need to Know" [Online]. Accessed on 2 April 2024, from <https://www.nrdc.org/stories/water-pollution-everything-you-need-know#whatis>
- [4]. Dikgale, Ntobela, K., Mendes, B., Tartibu, L., Kunene, T. and Bakaya-Kyahurwa, E. (2020), "Development of Solar-Powered Water Purification Systems" 9th International Conference on Appropriate Technology, Tshwane University of Technology, Pretoria
- [5]. Enzler, S. (2018), "History of Water Treatment" [Online]. Accessed on 15 September 2023, from <https://www.lenntech.com/history-water-treatment.htm>
- [6]. International Water Association (2023), "A Brief History of Water and Health from Ancient Civilizations to Modern Times" [Online]. Accessed on 3 April 2023, from <https://www.iwapublishing.com/news/brief-history-water-and-health-ancient-civilizations-modern-times>
- [7]. Khan, Z., Al-Mamun, R., Majumder, S. and Kamruzzaman, M. (2015), "Water Purification and Disinfection by using Solar Energy: Towards Green Energy Challenge" *Aceh International Journal of Science and Technology*, vol. 4, iss. 3
- [8]. Lin, L., Yang, H. and Xu, X. (2022), "Effects of Water Pollution on Human Health and Disease Heterogeneity: A Review" *Frontiers in Environmental Science*, vol. 10
- [9]. Pureitwater (2023), "Water Purification Methods and its Importance Explained" [Online]. Accessed on 8 April 2023, from <https://www.pureitwater.com/blog/post/water-purification-methods>
- [10]. Rank, S. (2020), "Solar Water Purification: A Starting Guide" [Online]. Accessed on 8 April 2023, from <https://gosun.co/blogs/news/solar-water-purification-a-starting-guide>
- [11]. Watters (2017), "A Brief History of Clean Drinking Water" [Online]. Accessed on 5 April 2023, from <https://scadata.net/brief-history-clean-drinking-water/?sfw=pass1712313201>
- [12]. World Health Organisation (2023), "Drinking Water" [Online]. Accessed on 2 April 2024, from <https://www.who.int/news-room/fact-sheets/detail/drinking-water>