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Manufacturing of Small Scale Water Treatment Plant for Household

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Abstract. Water is one of the essential resources in the world. Without water, the world cannot survive. Earth is covered by 71% water and 2.5 % coverd by freshwater. Out of 7 billion peoples, only 1.2 billion peoples are getting fresh water for drinking. The scarcity of water exerts strong effects around the world. The world is working to develop appropriate, cost-effective methods to provide high purified water for drinking purposes. Water contains suspended particles, micro-organisms, bacteria, organic and inorganic compounds as impurities. For purification, lots of methods are available which are widely used all around the world. This research is based on the research and development of water treatment plants which is cost-effective and provides safe drinking water for household purposes. Solar de-salination is one of the best energy efficient methods used for water treatment. In this process, solar energy is utilized to purify saline water. Minerals and salts were quickly removed as a brine solution and vapors condensed and collected to get the product. The energy requirement is low as compare to other methods. The construction of the plant was simple and cheap. This process removes 99.5 % of salts from the water. This research is successful in achieving the objectives and goals of getting potable water that meets the standards of WHO. This research also focuses on a large scale for water treatment as it is cost-effective and can reduce the shortage of freshwater around the world.

Keywords: brackish water, solar still, turbidity, total dissolved solids, hardness.

Introduction

About 71% of earth's surface is coverd by water and it plays a vital role in the life of planet and of world economy. A large amount of water is used for cooling and heating purpose in industries and homes. Finding and maintaining a clean water supply for drinking and other uses have been a constant challenge throughout human history. The availability of pure drinking water is in crisis all over the world and is increasing day by day. Water is polluted when harmful substances and often chemicals or micro-organisms contaminate an ocean, river, stream, lake, aquifer or other bodies of water, degrading its quality and rendering water toxic to humans or the environment. Finding the best suitable and cheapest method for water purification for household purposes is very difficult and these difficulties can be easily studied and demonstrated through a pilot plant (Cornejo *et al*., 2016; Larsen *et al*., 2016).

This research aims to make a water treatment plant that will provide clean water for household and also to solution to the salinity of the brackish water. The objective is to make a small scale plant that can be used in less space in the houses. The scope is to create a water treatment plant to produce de-salt water with meager cost and energy efficient, which can be scaled up for urban and deserted areas. It consists of a solar heater and solar still combined with feed and product tanks to produce purified distilled water with out of no source of electricity uses through out the procedure. The raw material used in this research is brackish water, which has some salinity. And after the treatment, the product is distilled water and the bottom product is a brine solution.

Water is based on its origin, consistency, composition and treatment and the effects in this description range from being highly specific to as general as to be non-definitive. Groundwater is found below the earth's surface in the cracks and spaces in soil, sand and rock. A part of the rock or an unconsolidated deposit is called an aquifer. The aquifer has large connected spaces from where water penetrates, it is stored as groundwater. Soft water contains a low concentration of calcium, magnesium, iron and other insoluble deposits. It is free

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from dissolved solids and safe for drinking. Hard water contains a high concentration of calcium, magnesium, iron and other insoluble deposits. It is not suitable for drinking.

Boiled water is free from disease-causing organisms, viruses, bacteria and pesticides but it contains inorganic minerals. Distilled water is known as purified water which is made by boiling the water and then condensing it in liquid form. It is free from germs and contamination. Freshwater is water found naturally from ice sheets, glaciers, ice caps, ponds, lakes, rivers and streams. It contains a low concentration of dissolved salts and other total dissolved solids. Water droplets falling from the clouds to the earth are considered rainwater. It is the first distilled water, but falling it combines with gases, dust, germs and other atmospheric chemicals. Seawater is a mixture of 95% water, 2.5-3% salts and a small quantity of dissolved inorganic and organic materials. It also contains atmospheric gases (Ahmad *et al*., 2016; Baig *et al*., 2015).

Past, present, and future of raw materials and product. The raw material put into the process is to feed water. The properties of feed water may vary from location to location and source. The source of feed water could be river water, seawater and brackish water. The properties are hardness, BOD, TDS, COD and mineral contents can be different in all. Using brackish water as a source for feed, its salinity is higher than freshwater but lesser than seawater. It can be found in underground aquifers or estuaries (Chiu *et al*., 2015; Singh *et al*., 2015).

Two products obtained from our water treatment process are distilled water and brine. Distilled water can be made drinkable by just adding specific minerals to it. As the population is growing day by day, the water shortage has become a common problem for all the people around the world. Due to the increase in demand for pure water, de-salination has become a viable solution. Now a day's de-salination is producing around 5% of the world's pure water. In most Arab countries de-salination is considered a significant source of purifying saline water. According to a study around 2030, the production from the de-salination process would be doubled. The brine solution we get as a bottom product can be further processed and used for a culinary purpose, refrigeration fluid, water softening and purification and de-icing (Levänen *et al*., 2015; Radjenovic and Sedlak, 2015).

Reverse osmosis. The process in which, a solvent is forced from a region of the high solute of low solute concentration through a semi-permeable membrane by applying pressure over the osmotic pressure. Reverse osmosis is the most widely used method. This process can remove both dissolved and suspended solids from water. The semi-permeable membrane used in this process restrict the flow of solids and allows the pure solvents to pass. This process produces high purified water which can be drinkable (Le and Nunes, 2016; Lu *et al*., 2016).

Electro-dialysis. It is an electrochemical separation process that employs electrically charged ion exchange membranes with an electrical potential difference as a driving force. This process is best for highly acidic and alkaline water. Maintenance cost is low as compared to other processes (Abbaspour *et al*., 2015).

Membrane distillation. Membrane distillation is a separation process, where a micro-porous hydrophobic membrane separates two aqueous solutions at different temperatures. The temperature gradient on the membrane results in a vapour pressure difference. There are two compartments, one with high vapour pressure (hot side) and the other with low vapour pressure (cold side). The vapours are transferred *via* diffusion and convection from a compartment of high vapour pressure to the compartment with low vapour pressure, where they are condensed in the cold liquid phase, de-mineralized water is obtained on the distillation side. There are different configuration modules to generate a vapour pressure difference across the membrane. The configuration modules are vacuum membrane distillation (VMD) direct contact membrane distillation (DCMD), air gap membrane distillation (AGMD) and sweep gas membrane distillation (SGMD) (Gwenzi *et al*., 2017; Love *et al*., 2015).

The advantages of membrane distillation are low working temperature and pressure, low energy cost, no chemical feed water pretreatment is required and low flux limitation. Dis-advantages of membrane distillation are low permeate flux, not feasible for commercial use, high cost of membrane distillation module, and fouling and scaling on the membrane.

Pratiksha D.Dongare, Alessandro Alabstri and Seth Pedersen determined direct solar membrane distillation driven by Nanophotonic mediated photothermal heating in a membrane distillation geometry. The feed water is vapourized by solar heating and consequently condenses on the distillate side of the membrane. The solar photothermal heating process does not require to heat the whole volume of feed water, it needs only to heat the water molecules which are on the surface of the membrane. This reduces the power requirements of the conventional membrane distillation. This method has an efficiency of 99.5% salt reduction and 20% solar efficiency. Fig. 1 shows the conventional membrane distillation and NESMD (Adeleye *et al*., 2016; Le and Nunes, 2016).

A photothermal, hydrophobic, 0.2 µm pore size polyvinylidene fluoride (PVDF) membrane is used with polyvinyl alcohol (PVA) coating deposited onto it. To make the membrane photothermal, a coating of carbon nanoparticles is needed. This techniques describe for the preparation of PVD membrane the "non-solvent induced phase separation" (NIPS) and "thermally induced phase separation" (TIPS). Among them, thermally induced phase separation offers more advantages. The raw material used is polyvinylidene fluoride (Mw =670–700 kDa), poly tetrafluoroethylene (additive), dimethyl phthalate (diluent), *n*-hexane and deionized water (Acien *et al*., 2016; Knopp *et al*., 2016).

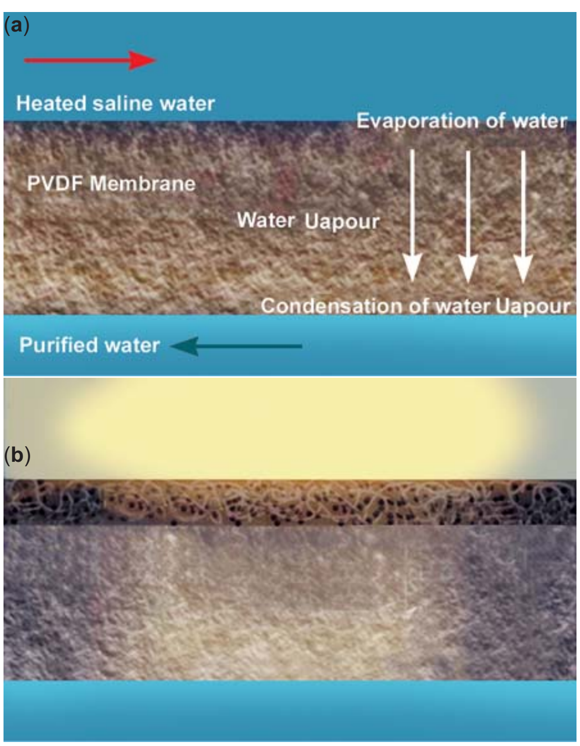

Fig. 1. Membrane distillation (**a**) Conventional (**b**) Nano photonics-enabled solar.

Multi-stage flash distillation (MSF). In this process, the water is first heated till evapouration and get purified by passing through a series of flash evapourators. Each subsequent flash process utilizes energy released from the condensation of the water vapour from the previous step and so on. The vapours formed by vapourization are collected by the condensation process to get the product. This process is cost-effective and produces fresh distilled water. Widely used in Industries for getting distilled water. A process in which we remove dissolve minerals from saline water is called des-alination. If the process is done through solar energy, it is termed solar de-salination. The world is facing difficulties in finding an energy efficient method for water purification and by utilizing solar energy for water treatment, we can make the process energy efficient.

Solar still is considered as a direct method for solar des-alination as evapouration and condensation are taking place in the same equipment as shown in Fig. 2. Solar still can be used for household purposes. It is a cost-effective process. Solar still is simple equipment that uses solar energy to convert saline water into vapour form and the impurities are commonly known as brine solution settle down. The vapour condenses at the surface of the glass, which is the cooling side of the equipment. The condensed vapours were then collected to get the desired distilled water (Cydzik-Kwiatkowska and Zielinska, 2016; Sawatdeenarunat *et al*., 2016).

Production description. Coagulation is a process of water/wastewater treatment in which the particles are removed from water by adding chemicals that neutralize the charge of the particles and allow them to stick together and make flocks and then the particles can be

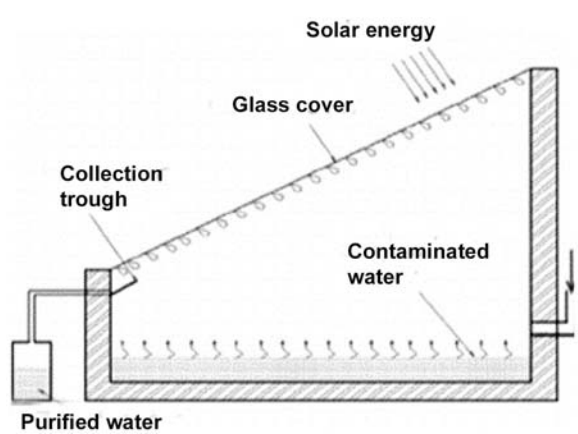

Fig. 2. Solar still.

separated by filtration or other methods. In this process, a chemical such as alum is added which provides a positive charge to the particles to neutralize them and allow them to stick together and form large particles. Organic matter can also be removed by this process, but it depends on the type of material present. Lower molecular weight species are difficult to separate on the other hand species with higher molecular weight are easy to separate. The limitations are that it requires further treatment of water as it only removes particles, only removes 60-70% organic matter and not feasible for large-scale commercial processes (Salama *et al*., 2017; Opher and Friedler, 2016).

Filtration is a process that removes particulates from a fluid (water) by using porous media. The presence of suspended particles such as clay, sand and silt causes turbidity in the water, which makes it reduce transparency. The transparency of water is important because it makes aesthetically pleasing. The porous medium used in infiltration can be a membrane, cloth, cartridge, screen or granular material. The filtration method can also be used as a biological treatment by using a bed of some chemicals to remove/ kill the micro-organisms. Rapid sand filtration is a physical process to remove suspended particles from water. It is a very common technique used for the treatment of municipal water. The filter media is usually sand, but it can be any appropriate medium. Because it is a simple physical process and only removes suspended particles and requires additional treatment of the water to remove micro-organisms. There are two types of rapid sand filters gravity and pressure type. The limitations are that it only removes suspended particles, requires pre and post-treatment and regular back washing is required to clean the filter media (Salama *et al.*, 2017; Koch *et al*., 2016).

Unlike rapid sand filtration and slow sand filtration is a physical and biological treatment process. As the name suggests that process is slow because the sand used is of low porosity. On the surface of the filter, there is a biological layer called 'Schmutzdecke' which consists of bacteria, fungi protozoa and other organisms. These organisms digest and metabolize the contaminants. Due to slow nature of process, the vast land is required for high product gain. After passing through the biofilm, the water flows through the sand, where the particles are remaining can be removed. This process has a very high efficiency of purifying water. The limitations are a very slow process and a large land requirement.

The artificially created sieves or films called membranes are used to filter water. It is a purely mechanical process that allows only selected particle sized to pass through it. A membrane is a semi-permeable material that separates substances by the action of a driving force such as pressure. According to the pore size, membrane separation is divided into operations. Micro-filtration is a membrane filtration process in which suspended particles and micro-organisms are removed by approximately 0.1 μm pore size membrane. The pressure requirement is low, about 100 to 400 kPa. It is a membrane filtration process in which small colloids, bacteria, protein and viruses are removed through approximately 0.01 μm pore size membranes. Due to the relatively smaller pore size, the pressure requirement is high around 200 to 700 kPa. It is a membrane filtration process in which dissolved organic matters and ions are separated through an approximately 0.001 μm pore size membrane. It has a very high pressure requirement of around 1000 kPa because of its very low pore size (Gwenzi *et al*., 2017; Hu *et al*., 2016).

De-salination is a process in which salts and minerals from the water are removed. The feed for this process is saline (salt) water, which can be brackish, seawater, wells and surface water, wastewater and industrial water. The degree of salinity in water affects the treatment process, the greater the salinity, more difficult it is to purify. The salinity is measured in parts per million (ppm), the water with 1000 ppm to 3000 ppm is considered as low saline, 3000 ppm to 10,000 ppm is considered as moderately saline and above 10,000 ppm is considered as high saline water. The de-salination process separates the feed saline water into two products, fresh desalted water and a brine solution. The freshwater has a low concentration of dissolved salts whereas, the brine solution has a high concentration. There are three de-salination techniques used widely thermal technology, membrane technology and chemical technology (Baig *et al*., 2015).

Thermal de-salination technology requires heating of saline water and a collection of condensed vapours, which can be used to produce pure water. Due to heating, the energy required for this process is high, which makes it costly. Thermal de-salination can be divided into multi effect distillation (MED), multi stage flash distillation (MSF), vapour compression distillation

(VCD) and solar distillation. Multi stage flash distillation (MSF) is a de-salination process that distil the feed saline water by flashing or evapouration. The feed water is heated under high pressure and then sent to the first flash chamber, where the pressure is released causing the water to evapourate suddenly. There is more than one stage and in each successive stage the pressure is reduced to make sure the evapouration is complete. The vapours from the chambers are collected and condensed to produce pure water. The MSF is a reliable process proven for years, there are some advantages and disadvantages of the process. The most important disadvantage is that it has a very high energy requirement. They are subject to corrosion, but it can be reduced by using stainless steel. Around 70 % of the world's de-salination is done by MSF (Al-harahsheh *et al*., 2018).

Multi effect distillation (MED) is a process that has multiple effects or stages, at each stage, the feed water is heated *via* steam. This process uses a low temperature and pressure to evapourate water and the vapours of the first stage are used as a heating source for the second stage that's why the heat requirement is low for other stages. The seawater after heating up to the boiling point and then sprayed on the tubes of the evapourator is evapourated rapidly (Amy *et al*., 2017).

Vapour compression de-salination is a process in which evapouration takes placed by the application of heat given by compressed vapours. Its boiling point decreases by a reduction in pressure. There are two methods used to condense the water vapours mechanical compressor and steam jet. Reverse osmosis technique various containments or dissolve salts by using a semi-permeable membrane by applying high pressure through the pump. But it does not remove very small particle because it is a semi-permeable membrane which allows very small particles to pass from it. The solvent had high solute concentration flow towards low solute concentration which is a reverse process of naturally occurring osmosis. It's operating maintenance cost and salt rejection are high.

Material and Method

Process selection and detailed process description. The method selected by us is solar de-salination through solar still. Because it uses only solar energy as a source of heating and does not require any mechanical and electrical energy, which makes it cost efficient. It is a slow process but it can be optimized through various techniques. It is based upon energy and time requirements, financial feasibility, footprint, location, ergonomics of the system, operability, portability, scale of the project, type of feed, resources present and future scope of modification. It is extremely cheap and does not require any electrical energy, it runs completely on solar energy. It gives a salt rejection of more than 99%.

The feed water is obtained from the well it is first fed into the tank and then the ball valve is open to flow towards the solar heater through rubber piping, where it is heated. It absorbs heat in the solar heater by giving it ample time. Then hot water flows through that copper coils towards the solar heater, flow is dependent upon as height there is no pumping device is installed, so after the solar heater, it reaches the solar still, where vapours generated due to the temperature difference of surface of the solar still and transparent glass which is placed inclined and thus condensate collected on a collector which is made up of PVC pipe and thus the product is collected in a product tank due to gravity bases. The amount of de-salinated water collected depends upon the sunlight available, absorptivity and residence time.

For the sake of increasing the volume of produced water, an external modification is made, the type of solar heater is increases the production rate, residence time and absorptivity. Another modification is used to reduce energy requirement, the height of feed is set to increase the hydrostatic head. The internal modifications which are done are copper tubing used in the solar heater to increase the thermal conductivity, a black coating used to increase the absorptivity and rubber pipingused to minimize the heating loss as given in Fig. 3. After these modifications, the energy requirement is lowered and production capacity is increased. The primary source is solar energy, other forms of external energy can be used as electrical energy or mechanical energy.

Equipment design and fabrication. The feed tank is a PET water bottle used in our home, but there is some modification done to it. It is cut from the bottom from, where we pour our brackish water into the tank because it is placed reverse into the stand and a ball valve is placed in its opening by using silicon to avoid any leakages. It is placed in sunlight because water absorbs some of the heat content which will make it slightly easier for solar heat to heat. It requires some head that's

Fig. 3. Project in running condition.

why placed on top of the stand 6ft above the ground and volume 19 L.

The solar heater consists of a wooden body and copper coils. The body of the solar heater is made up of wood to make it non conductive because we need less heat loss. There are two sections of the body, 20" x 20" each. Both sections are covered with a glass of 20" x 20" having a thickness of 3mm on the top to trap the heat as shown in Fig. 4.

A standard ¼ inch outer dia and 0.02" wall thickness copper tubes are used. A 100 ft. The long coil is placed in the solar heater 50 ft. the coil is placed in one section of the heater and 50 ft. the coil in another section. The coils are arranged in a circular shape to accommodate less space as shown in Fig. 5 (a).

The solar still consists of the different components are removable sliding glass, discharge tube, feed water inlet, discharge of brine water, overflow opening and temperature indicator. The body of solar still is made up of acrylic, which is lightweight, cost-effective and durable. The dimensions of solar still are shown in Fig. 5 (b). There is a black silicone coating inside the still to prevent heat loss and to increase the absorptivity. The top of the still is covered with a removable glass to allow cleaning of the still. The glass is used as a condenser, the vapours condense on it, and the glass is placed with an angle of about 48 degrees so that the

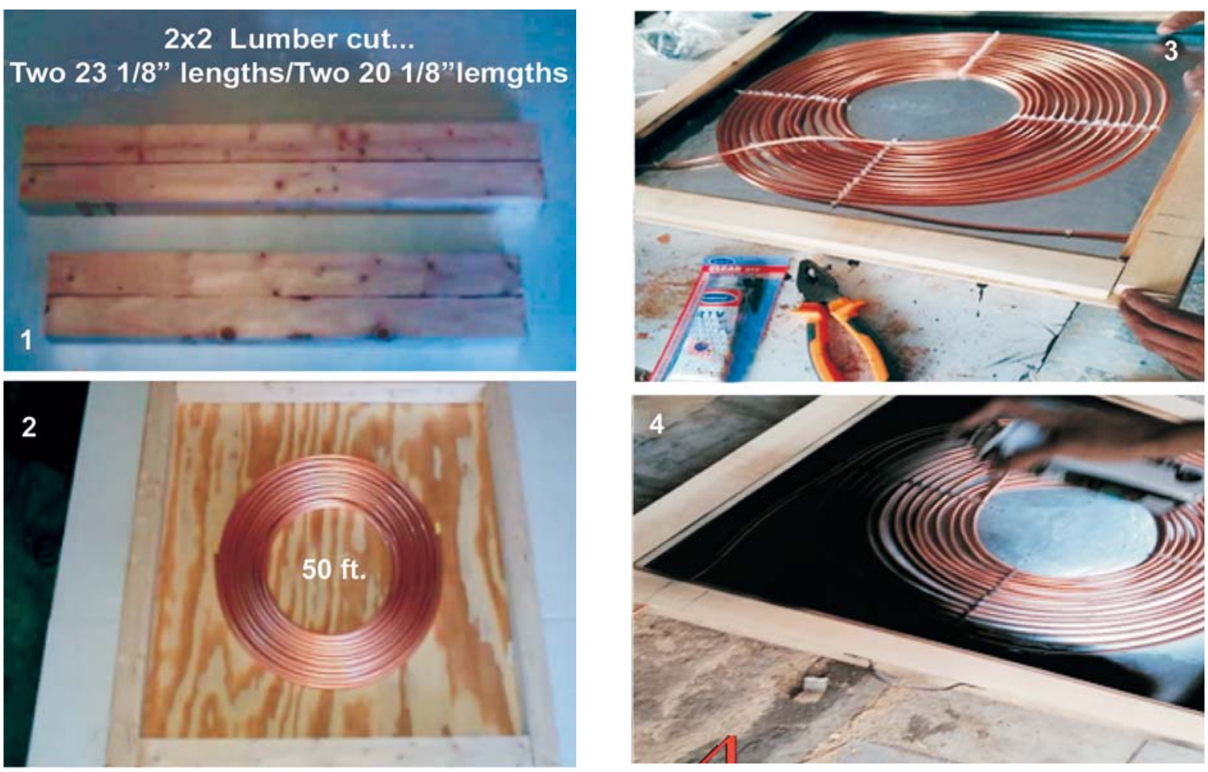

Fig. 4. Step by step construction of the solar heater.

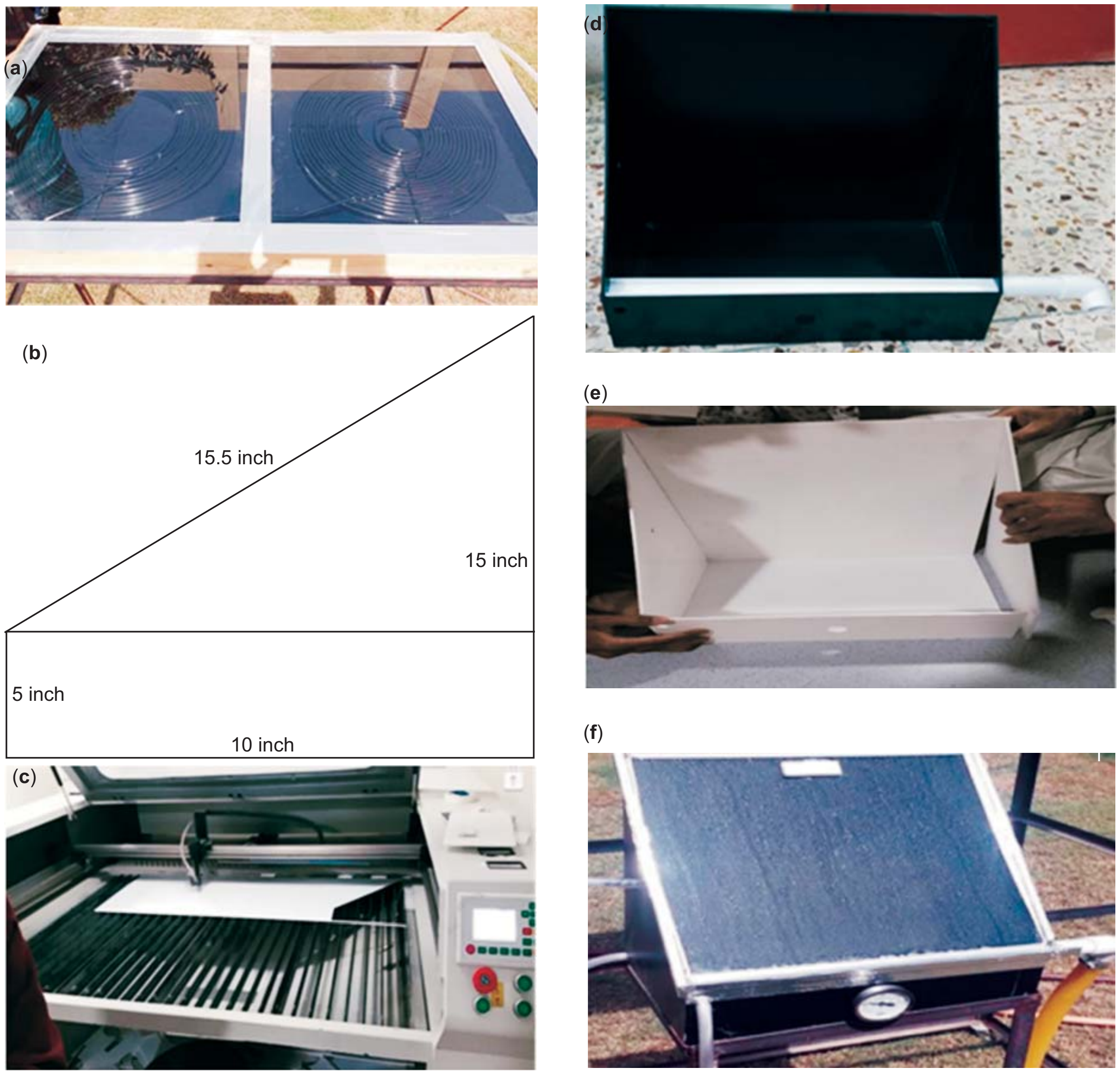

Fig. 5. (**a**)Solar heater (**b**) Dimensions of solar still (**c**, **d**, **e**, and **f**) steps of construction.

vapours slide down to the discharge tube. There is a discharge tube placed below the glass end to collect the vapours, a PVC pipe is cross sectioned so, that the vapours collect in it and it is placed with an angle so, that the product can be collected through a pipe and the steps of construction are shown in Fig. 5 (c, d, e, and f). There is a feed opening on the center of the left side of the still. There is a brine discharge opening on the bottom of the still, where a ball valve is placed. An overflow opening is also made which is just below the discharge tube so, that the brine water does not enter the tube and volume 9.22 L.

A ball valve is a quarter turn valve that uses a hollow ball to control flow. When the ball is in line with the flow, it is open. There are three 0.25 inch ball valves used, one on the discharge of the feed tank, one on the discharge of the solar heater and one on the discharge of the solar still. Rubber pipes are used with an inside diameter of ¼ inch. Rubber pipes are used to reduce heat loss. A bimetallic temperature gauge is used in the solar still to check the temperature of hot water. A hollow cylindrical metal tube is filled with a liquid, usually alcohol. The tube is sealed at both ends and is coiled at one end which is connected by a pointer. The other end stays in the substance that needs temperature sensing. As the temperature rises, the fluid in the tubing heats up and increases in volume which builds up the pressure at the coiled end, and hence it moves. Although the motion is quite tiny a special gear assembly is employed which magnifies the motion and displays it on a pointer scale.

The stand is made up of steel and designed to fit all the equipment. The height of the stand is 6 ft. and the width is 5.5 ft. There are three floors, on the top, the feed tank is placed to provide hydrostatic pressure. On the second floor just below the feed tank, the solar heater is placed. On the first floor solar still is placed. The product tank is placed on the ground and the process flow mechanism is shown in Fig. 6.

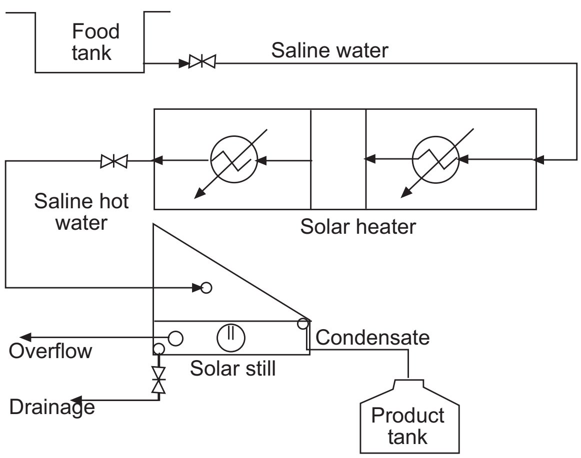

Fig. 6. Process flow mechanism.

Result and Discussion

The feed tank is filled with brackish water by opening a valve then it flows towards the solar heater through a rubber pipe and is heated in a solar heater. For some time through solar energy by using copper tubes by opening the discharge valve, it has flow towards solar still, where vapours are generated and vapours are condensed on a transparent glass. Hence distilled water is collected in a product tank and the operating conditions are given in Table 1.

Framework productivity is communicated by condenser effectiveness because the condenser encourages the condensation of a hot vapour in a tube framework utilizing water streaming over the tubes. The framework of cooling water furnishes the condenser with the essential cooling for the creation of adequate condensate. Along these lines, as the temperature distinction among cooling water temperature rises of inlet and outlet, the condenser proficiency just as framework productivity increases (Al-harahsheh *et al*. 2018; Pouyfaucon and García-Rodríguez, 2018; Amy *et al*. 2017). The experimentations are done on different equipment arrangements and weather conditions. Solar heater without solar still in sunny and cloudy weather. Solar heater with solar still in sunny and cloudy weather. Solar heater with solar still using the bulb.

Table 1. Operating conditions

Component	Parameter
Feed type	Brackish water
The volume of the feed tank	19 gal
Heating medium	By solar heater, direct heating from the sun
Temperature sensor type	Analog
Inlet temperature	28 °C
Outlet temperature	Up to 70 °C
Water flow rate	0.408505 liters per batch
Volume of tubes	0.81701 liters
Ambient temperature	30 °C
Time per batch	15 min.

The climatic conditions variety (sun based radiation and surrounding temperature) as for time throughout experimentation. Figure 7 (a) shows the solar heater without solar still in sunny weather. Figure 7 (b) shows the solar heater without solar still in cloudy weather. Figure 7 (c and d) shows the solar heater with solar still in sunny weather and cloudy weather. Impact of some various parameters on frameworks temperatures against day hours for brackish water for the sunlight based de-salination through sun powered still sub merged tank stream rates are given in Table 1. It very well may be seen that every single estimated temperature expanded dynamically with sun based radiation through day hours for the sun oriented de-salination frameworks. It is seen that vapour temperature noted the most elevated qualities contrasting with every single other temperature. Vapour temperature arrived at their most extreme qualities at 2.0 p.m. Afterward at 2.0 p.m., vapour temperature diminished because of the decreased impact of sun-powered radiation (Pugsley *et al*., 2016; Reif and Alhalabi, 2015).

Figure 7 (e) shows the solar heater with solar still using the bulb. The hourly production of both sun based de-

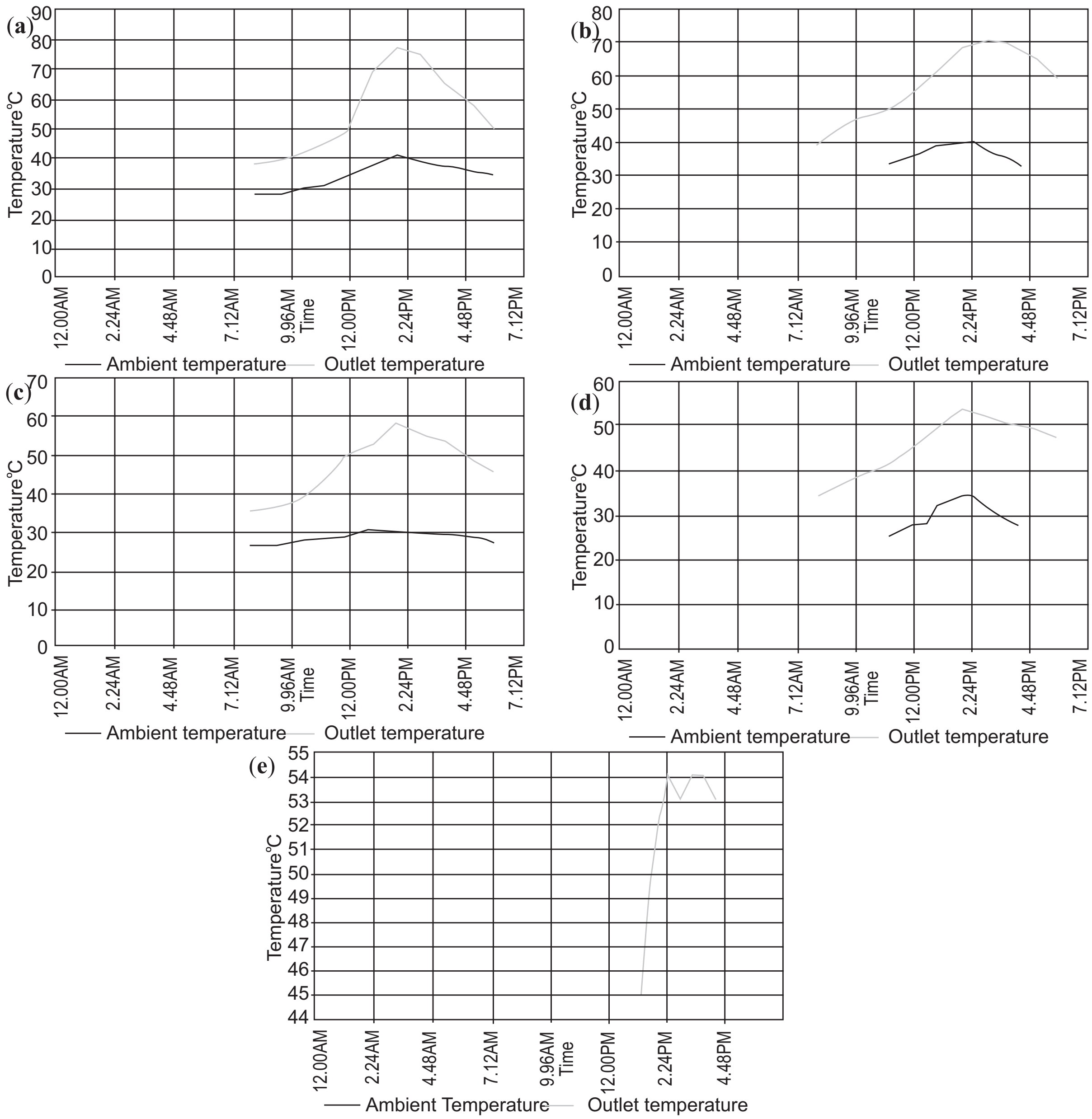

Fig. 7. (**a**) Solar heater without solar still in sunny weather (**b**) Solar heater still in cloudy weather (**c**) Solar heater with solar still in sunny weather (**d**) Solar heater with solar still in cloudy weather (**e**) Solar heater with solar still using the bulb.

salination (sun based radiator with and without sun-powered still) frameworks demonstrated that the most extreme qualities were seen at 2.0 p.m. under every single exploratory condition. The outcomes indicated great concurrence (Al-harahsheh *et al*., 2018; Amy *et al*., 2017). A diminished boiling point of water brings about a high di-ssipation rate, which expands water efficiency underutilizing the created sun powered controlled de-salination framework. The greatest production must have corresponded to the most extreme temperatures and sunlight based radiation. The lowest efficiency occurred in the morning and night hours, where low temperature and low sunlight based radiation ensued.

This research conducted various water quality tests for feed and product. The feed is brackish water and the product is distilled water, the results are given in Table 2. This method gives 99.8% salt rejection.

Table 2. Brackish and treated water test results

Parameters	Feed brackish water results	Product treated water results
TDS	5200 ppm	10 ppm
pH	8.3	6.9
Hardness	1250 ml/L	30 mg/L
Turbidity	3.8 NTU	1.5 NTU

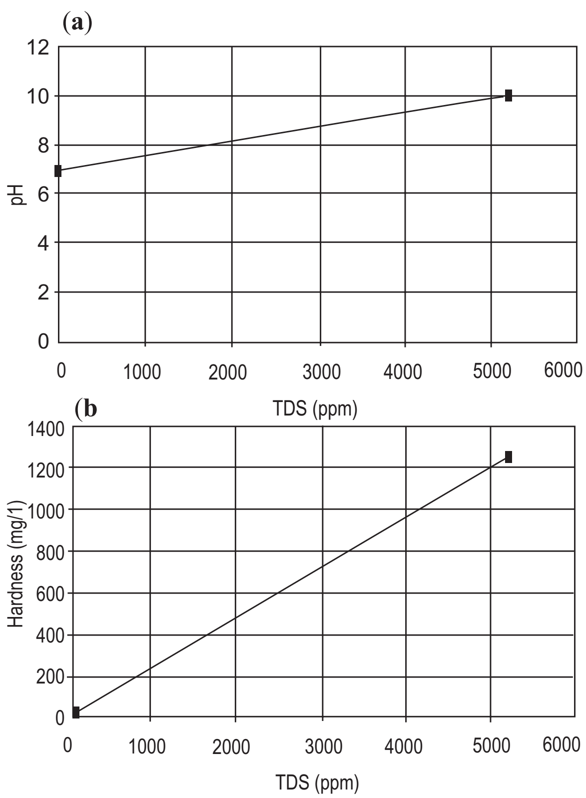

Fig. 8. (**a**) Relation between TDS and pH (**b**) Relation between TDS and hardness.

$$\% \text{ Salt rejection} = \left[\frac{TDS_{in} - TDS_{out}}{TDS_{in}}\right] \times 100$$

$$\% \text{ Salt rejection} = \left[\frac{5200-10}{5200}\right] \times 100 = 99.8\%$$

According to the results, the TDS and hardness of the feedwater reduce extremely as shown in Fig. 8 (a and b) respectively.

Identifying with the impact of saltiness level on crisp water production, the new water efficiency is more noteworthy for bitter water, Mediterranean seawater and the most minimal for Red seawater because the TDS of water expands its boiling point, as its molecules group and because stiffer to boil. As the saltiness of the water expands, its density rises and its vapour pressure diminishes. The expansion in density and decrease in vapour pressure lessen the viability of the capillary forces in rising the water to the highest point of the level plat solar collector to dissipate. From the literature, it tends to be seen that freshwater production diminished by expanding the scope of saltiness level. The acquired outcomes demonstrated great concurrence. From the past studies, it very well may be inferred that the solar desalination frameworks can work with an elite with brackish waters (Al-harahsheh *et al*., 2018; Chaichan *et al*., 2016; Arunkumar *et al*., 2015; Gorjian and Ghobadian, 2015).

Conclusion

After performing experiments and observations, the results are showing that this concept works and is used for small scale purposes like households, especially in deserted areas, where school laboratories need distill water to perform experiments and they have enough resources to produce distilled water. This kind of salt rejection makes this prototype an amazing concept among all. We can scale up this prototype by doing some optimization to reduce heat losses through valves, wind and piping. The length of the tube may be increased to give more residence time which increases production capacity. By using the Fresnel lens, its production capacity can be extremely increased by increasing its absorptivity. Seawater can also be used as a feed but after its pretreatment. However, quantity is less as compared to other techniques but remarkable energy efficiency makes a new development in the world where water and energy both crises are at peak.

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Conflict of Interest. The authors declare no conflict of interest.

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