DESIGN AND FABRICATION OF SOLAR WATER PURIFIER USING THERMAL METHODS: A RESEARCH ON SOLAR STILLS

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CERTIFICATION

This is to certify that this project, **DESIGN AND FABRICATION OF SOLAR WATER PURIFIER USING THERMAL METHODS: A RESEARCH ON SOLAR STILLS,** was carried out by AZIKEN ODAFIN RICHARD **(ENG1704274),** BRAIMAH ELIJAH **(ENG1704278),** BAZUAYE DAVE OWENOSA **(ENG1704275**), BENSON STANLEY ONORIODE **(ENG1704277)** in the department of Mechanical Engineering, Faculty of Engineering, University of Benin.

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DEDICATION

This project is dedicated to God almighty, and to all those who have supported us through our academic journey so far.

ACKNOWLEDGEMENT

We appreciate **ENGR. DR. H. O. EGWARE**, the project supervisor, for his invaluable input, advice, and support, which motivated us to work even harder. Our sincere gratitude also extends to our cherished parents for their moral and emotional support, as well as their prayers and words of wisdom throughout our time at the University of Benin. A heartfelt thank you also goes out to all the members and employees of the Mechanical Engineering Department at the University of Benin in Benin City, led by **PROFESSOR GODFREY OMONEFE ARIAVIE**.

ABSTRACT

Our focus in this project is to address water scarcity by creating a simple solar still system that will increase water productivity. The solar still uses simple design features to transform non-potable water into a secure and useful resource. It does this by employing strong materials and an effective water purification system. Optimized sunlight exposure angles, enhanced heat retention, and technology that guarantees continuous water production even in times of low sunlight are some of the key features.

Thorough field testing in regions with non-potable water sources assesses the system's functionality under varying conditions. Participation from the community is essential, as input directs system optimization for cultural appropriateness and usability. The project also places a strong emphasis on building sustainably and cheaply by using local resources. A thorough documentation process records the phases of testing, construction, and design iterations, offering important information for upcoming implementations and enhancements.

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CHAPTER 1. INTRODUCTION

1.1 BACKGROUND TO STUDY

As our modern society continues to expand and develop, the demand for freshwater grows rapidly, exerting immense pressure on ecosystems. Water scarcity poses a significant survival challenge in many parts of the world(Yadav & Prakash, 2023). Water is undeniably essential for human existence, playing a vital role alongside food and air. It serves as a primary resource for industries and urban areas, supporting various activities vital to our daily lives (Cordon, 2016).However, this essential resource is increasingly depleting due to factors such as pollution and population growth resulting from modernization. Water scarcity has become a critical survival challenge in numerous parts of the world, affecting communities and ecosystems alike (Yadav & Prakash, 2023). The demand for clean water has surged by an alarming 600% in the last century, attributing to the expanding needs of our growing population and industries. Freshwater resources, predominantly found in rivers, lakes, and underground reservoirs, account for a mere 2.5% of Earth's total. Shockingly, only 0.3% of this freshwater exists in liquid form on the surface, emphasizing the scarcity of accessible water sources. In many rural communities, the absence of safe and clean drinking water sources is a prevalent problem. The consequences of water scarcity are particularly severe for vulnerable populations, with children bearing the brunt of its impact. UNICEF reported that 70% of water at the point of consumption is contaminated, causing detrimental health effects, especially among children(Voice of America, n.d.). Nigeria, tragically, experiences the highest number of water-related illnesses among children, resulting in the loss of 117,000 young lives annually(Voice of America, n.d.). This grave situation necessitates immediate attention and sustainable solutions to mitigate the devastating effects of water contamination on vulnerable communities. The escalating pollution and population resulting from industrialization, transportation, and related factors exacerbate the depletion of surface freshwater resources, intensifying the water scarcity issue(Yadav &

Prakash, 2023). Access to safe and clean drinking water remains a prevalent issue in rural communities. While technologies like seawater desalination show promise in combating water scarcity, challenges such as electricity consumption in Africa hinder their widespread adoption. However, solar water distillation emerges as a practical solution to address these challenges. Solar water distillation utilizes solar energy to effectively remove harmful substances from water, ensuring the provision of safe drinking water. This approach offers a safe and cost-effective method to guarantee access to uncontaminated water. Improving and optimizing the performance of solar stills is essential to producing more safe and drinkable water to meet the growing demand for clean drinking water. By improving the efficiency and scalability of solar distillation technology, we can further alleviate water scarcity and promote sustainable access to clean water for communities in need.

Solar distillation is the process of extracting salts and other impurities from water using the sun's energy (Solar Energy). Distillation is one of many water purification techniques that can employ any heating source. In this paper, we will be looking at solar distillation using solar stills. A solar still works by sun radiation passing through its glass cover and heating the saline water in its center trough, some of which evaporates. This condenses on the underside of the glass, dissipating heat into the environment. The fresh water film on the glass collects in troughs on each side of the still.

Despite Numerous research and analysis of various reports such as(Ayoub & Malaeb, 2012) and (El-Sebaii et al., 2015) review the importance and usefulness of solar stills in the desalination of brackish water, sadly these reports do not review the effect of the solar still on rainwater, muddy water and rivers of third world countries, to add to the effect of the cost benefit analysis of the material and method used and comparison to other local methods of water purification. Consequently, this research aims to fill in the gap from previous research as well as determine the effectiveness of other variations of elements like fins, filters and condenser in the time and rate of water purified.

1.2 STATEMENT OF PROBLEM

According to WHO (World Health Organization), Despite the fact that 70% of the Nigerian population has access to basic water supplies, only roughly 19% of the population has access to safe and clean drinking water (Solihu & Bilewu, 2021).

The reason behind this project is the scarcity of clean water sources and the abundance of impure water that can be converted into drinking water. Moreover, there are several coastal areas where seawater is abundant, but access to clean water is limited. Additionally, the cost of purchasing and utilizing filtration and deionizing systems is high, and these systems do not completely purify the water by eliminating all impurities.

1.3 AIM OF STUDY

This study aims to design and construct a water distillation system that can purify water from brackish sources to a drinkable state according to WHO standard, a system that is relatively cheap, and portable.

1.4 OBJECTIVE OF STUDY

i. To design a home size water purifier that will produce of distilled water for drinking and domestic use from brackish water or saline water.
ii. To construct the home size solar water purifier using available local materials.
iii. To evaluate the performance of constructed solar water distiller and determining from data, the most effective variation of the purifier based on cost and effectiveness analysis

1.5 SIGNFICANCE OF STUDY

i. The study upon completion will provide a distillation unit that will purify water from brackish sources, a system that is relatively cheap and depends only on Thermal methods which we have taken solar energy to be our source as we have determined from previous studies that it is the most cost-effective method. This project is set prove and establish that.

ii. The project study will also help to reveal the most cost-effective material to build a solar purifier as well as determine from data gotten which variation of the purifier is the most effective iii. This study is also set to determine the viability of the project in the daily lives of

Nigerians that do not have access to clean and drinkable due to technological gap.

1.6 SCOPE AND LIMITATIONS OF STUDY

The study covers and is limited to the use of simple yet effective technology to design and construct a water PURIFIER that can purify water from nearly any source, a system that is relatively cheap, portable, and depends only on solar energy.

The major limitation to the study is that the only thermal method feasible is solar energy as well as the constraints in using cost-effective materials to provide data. Solar energy does not heat the water to boiling point, a lot of germs and contaminants are not entirely eliminated making the pure distillate unsafe for drinking. In case of higher demands of water, it is not economic to employ solar stills, due to low productivity.

1.7 METHODOLOGY

The primary goal of this design is to create a new system that is more reliable in terms of purification, water treatment and collection while taking in consideration the cost of material used to achieve the objective and analyzing the data gotten to determine if the design is viable for every run-off-the-mill Nigerian who cannot access technology.

CHAPTER 2. LITERATURE REVIEW

2.1 INTRODUCTION TO SOLAR STILLS

Desalination is the process of removing salt and other minerals from ocean water in order to produce clean water. Fossil fuels or alternative energy sources, such as biomass, wind, solar, geothermal energy, or industrial waste heat, can be used to generate the energy needed for desalination. solar stills have a number of advantages over other sun desalination techniques, including affordability, lower maintenance costs, simplicity, and minimal environmental effect.

A solar still is a device used to desalinate salty or brackish water that is unclean. It is a simple system that uses solar energy as fuel to distill impure water into potable/drinkable water for use in a variety of residential and industrial applications. The fundamental idea behind harnessing solar energy to transform contaminated, brackish, or otherwise salty water into consumable fresh water is actually fairly straightforward. If water is left in an open container in the open air, it will evaporate. This evaporated (or distilled) water is what a solar still is designed to collect by condensing it onto a cool surface.

2.2 TYPES OF SOLAR STILLS

Design or energy source can be used to classify solar stills. Based on design, we have tubular solar stills, spherical solar stills, hemispherical solar stills, pyramid-shaped solar stills, semicylindrical solar stills, single slope single basin solar stills, double slope single basin solar stills, and 'V'-type solar stills. Nonetheless, solar stills with a single slope or a double slope are commonly utilized.

In terms of energy supply, solar stills are classified into two, namely passive or conventional and active solar stills.

Passive or conventional solar still relies only on solar energy for thermal energy. For active solar stills, extra thermal energy from a solar collector or any accessible waste heat is sent to the solar still for quicker evaporation. The humidification-dehumidification (HD) method is a solar active technology.

Solar stills are the most basic equipment for obtaining freshwater with solar energy as the primary energy source.

2.2.1 Passive Solar Stills

Solar still systems that use solar energy as their major source of heat energy, as well as combine solar thermal energy to directly heat water and achieve the distillation effect are called passive solar stills. This type of solar still is characterized by low operating temperature and vapor pressure.

The heat form of solar energy initially employed in conventional passive solar stills to raise the water temperature and supply the requisite energy to transition from the liquid to the vapor phase. On the other hand, a novel technology that may be able to address some of the problems with traditional passive systems is the integration of photovoltaic modules with solar stills.

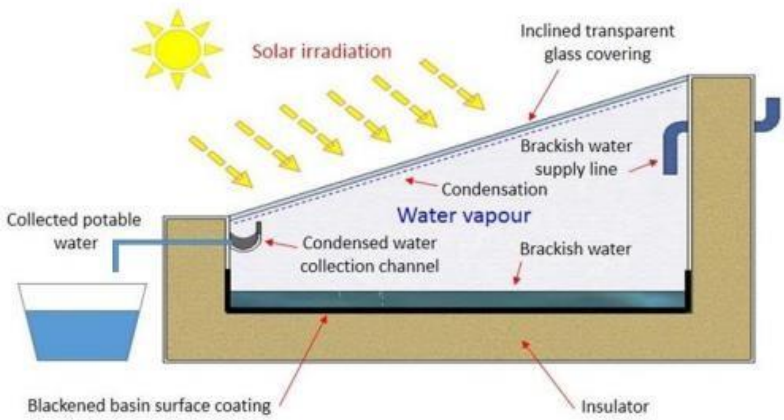


Fig 2.1 a typical passive still

During operation, By absorbing sun energy, the water in the basin gets heated and eventually evaporates. The water vapor that is produced condenses on the transparent glazing's underside..

This heat loss reduces the solar still's efficiency to under 40%, while affecting its condensate production rate drastically. In light of the traditional passive solar still's low productivity and efficiency, alternative still type of the traditional models are the key to overcoming its limitations.

An environmentally beneficial method of water treatment is a passive solar still. A passive solar still has the advantages of having no moving components, not requiring any specific filters or membranes to function, and—best of all—not requiring any power to carry out the distillation process.

2.2.2 Active Solar Stills

In this type of solar still additional thermal energy is combined with passive solar for faster vaporization and can be obtained from a sunlight collector such as the solar panel or slightly surplus heat energy produced by any industrialized area.

Solar stills were quickly adapted for their simplicity, low maintenance cost and the fact that electricity is not required, however water productivity of this conventional solar distillers is not attained. This led to the research and investigation of several methods to improve the performance and water productivity. Additional parts or apparatus are integrated with the still to improve overall performance. In recent years, the integration of pre-heated water from solar ponds, pumps, fans, condensers, as well as heat exchangers has all been investigated.. As a result, active sun thermal stills, in contrast to passive solar thermal stills, need additional energy sources, such as electricity to run pumps, fans, and other devices.

Another way to improve solar still performance is the integration of reflecting mirrors to capture more solar irradiation. Additionally, studies have demonstrated that sun-tracking devices can enhance thermal efficiency by more than 30-50%. The use of flat plate collectors as well as reflecting mirrors can often increases the water production of a solar thermal still due to increase in evaporation. Furthermore, it has been proven an integrated solar collector field could enhance a solar thermal system's functionality. even further. This research discovered that basin water heating occurred mostly during the day and far less as the day approaches night-time. This prolonged heating time resulted in greater temperature variations, resulting in the still generating at least twice as much purified water as the passive system. The performance of single basin solar thermal stills can be improved by using evacuated tube solar collectors. These systems may rapidly elevate basin water temperatures while achieving thermal efficiency below 35%. More findings have focused into gathering solar irradiation across a vast region and then channeling it onto a tiny area.

Solar stills can also be classified into Single effect and multi effect stills.

2.2.3 Single effect Solar stills

Fig 2.2-2 depicts the key components of a single-effect solar still. It consists of a thermally insulated basin with a black absorber and an angled semi-transparent condenser. The basin is filled with seawater. Solar energy is absorbed by the absorber after passing through the condenser and water. Solar energy is absorbed, heating and evaporating water. Water vapour condenses when it comes into touch with the condenser's inner surface and runs down to a collecting channel, where it is emptied into an external container. The highest efficiency of these solar stills is approximately 34%, and production declines noticeably as basin water depth increases. The cover condenser's tilt should match the latitude for the best distillate yield, and production is increased by thinner glass cover thickness. Due to the fact that it minimizes heat losses through the bottom and side walls, insulation is crucial in solar distillation (Kaviti et al., 2019).

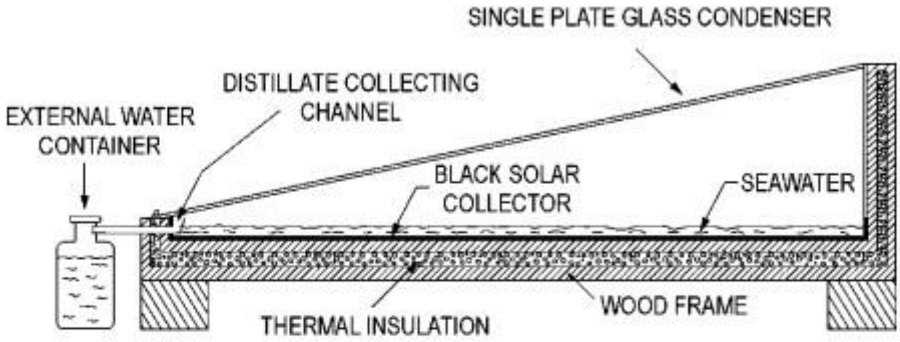


Fig 2.2 Single-effect single-slope condenser solar still.

2.2.4 Multiple-effect solar stills

Multiple-effect solar thermal stills outperform single-effect solar stills regarding their thermal efficiency and water output rate. For instance, water vapor from one basin may condense on the bottom of another, releasing latent heat of condensation that helps hasten the second basin's evaporation, as shown in Fig. 2.2-3(c). Therefore, low thermal efficiencies and low water productivities observed with single-effect solar stills are addressed by the design of multipleeffect solar thermal stills (Rajaseenivasan et al., 2013). Several different types of evacuated tube collectors, solar collectors, solar ponds, and heat exchangers have been integrated with multiple-effect solar stills. Studies h performance of multiple effect solar thermal stills is improved by the incorporation of evacuated tube collectors.

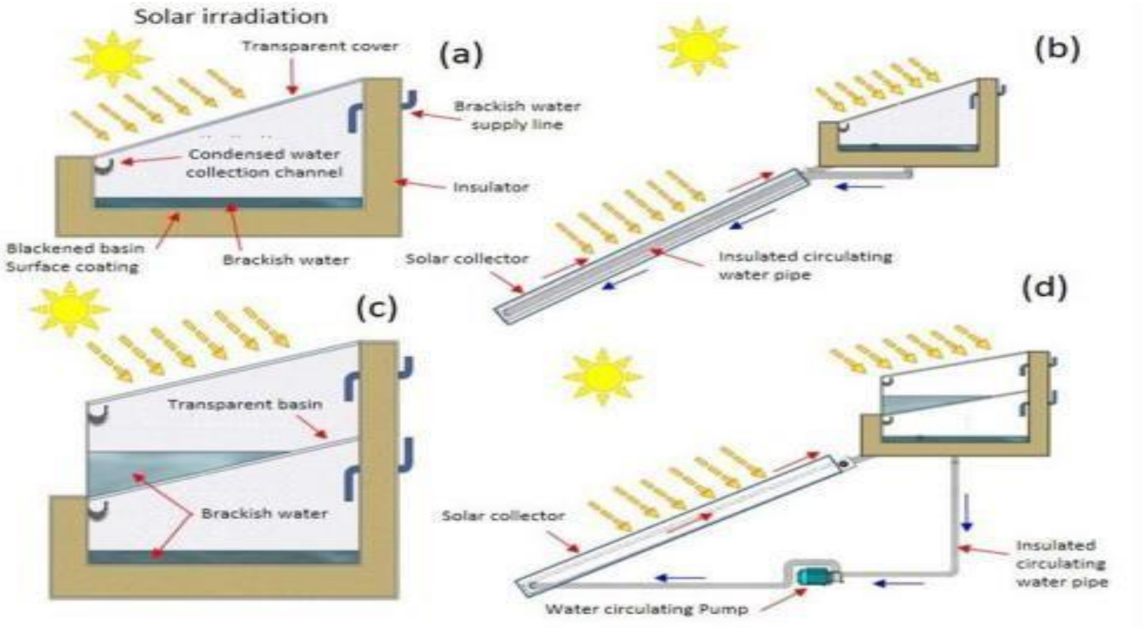


Fig 2.3 Diagrams showing the operation of four different types of solar stills: (a) passive single effect, (b) active single effect coupled to a collector in the natural circulation mode, (c) passive multi effect solar still, and (d) active multi effect coupled to a collector in the forced circulation mode.

2.3 THE PRINCIPLE GUIDING THE OPERATION OF SOLAR STILLS

The solar distiller includes a shallow black basin that has been designed to hold brackish water and absorb solar energy from the sun. As water evaporates from the salty mixture, it condenses on the underside of the glass cover that is sloped down, flows into the trough, and is eventually collected in a tank at the bottom of the distiller. The principle of operation is described below.

Solar radiation is reflected and absorbed by the glass cover before being transmitted inside the distiller unit's enclosure. The water mass partially absorbs the radiation that is being transmitted and partially reflects it. The radiation that is being transmitted further reaches the blackened surface, where it is mostly absorbed. The brackish water in the basin then uses the thermal energy absorbed, and the remaining thermal energy is lost in the atmosphere by conduction through the insulated bottom and sides of the distiller unit. When the water mass in the basin is heated by the basin liner's convection of energy, internal heat transfer from the water surface to the glass cover occurs at a temperature greater than that of the glass cover. Radiation, convection, and evaporation are the three methods of transferring heat. The latent enthalpy is released to the condensing surface, causing the evaporated water to condense on the inner surface of the glass cover. Condensate flows gravitationally into the collection troughs at the lower edge of the glass cover as a result of the cover's slight inclination. The cover has a steep enough slope that the condensate water's surface tension causes it to flow into the collection trough alone, without returning to the basin. Ultimately, the container is gradually filled with condensed water. The collected water is removed from the system and put to good use. The thermal energy that the glass cover receives from the outside is lost to the surrounding air through convection and radiation.

2.4 BACKGROUND ON THE SOLAR STILL

For a long time, distillation has been thought of as a technique to make saline water drinkable and to purify water in isolated areas. Aristotle first outlined a technique for purifying water by condensing polluted water as early as in the fourth century B.C. However, Arab alchemists in the 16th century produced the oldest known work on solar distillation. (Mouchot, 1869). Della Porta (1589) used wide earthen pots, as shown in Fig. 2.4-1 exposed to the sun's high heat to evaporating water and collecting the condensate into vases positioned beneath (Nebbia and Mennozi, 1966) (G.N. & Tripathi, 2003).

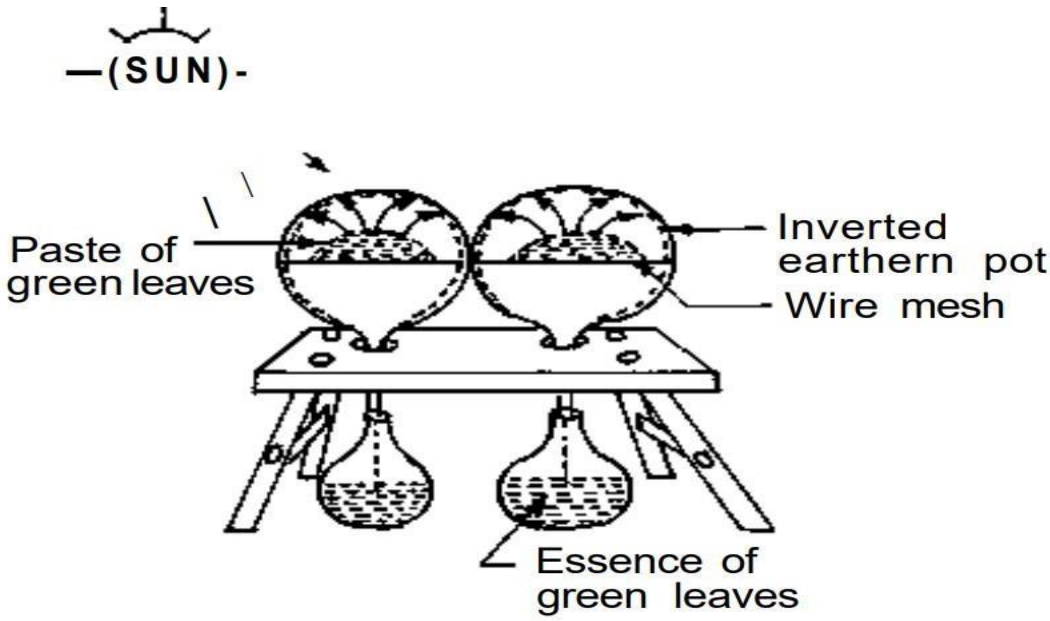


Fig 2.4 Historical solar distillation apparatus

Charles Wilson constructed the first contemporary solar still, built in 1872 in Las Salinas, Chile. It was constructed using 64 water basins, totaling 4,459 square meters, each with a glass lid and blackened wood construction. Animals working in mines received water from this installation (20,000 liters per day). The facility was let to decay once this location was made accessible to the outside by railroad, although it was still in use in 1912, or 40 years after it was first built. Most stills constructed after then have been based on this idea (Cooper, 2011).

The goal of almost all efforts to create substantial centralized distillation plants was to reignite interest in solar distillation during the 1950s. In California, it was planned to build plants that could produce 3,775 cubic meters, or 1 million gallons, of water per day. But after around ten years of study, academics from all over the world came to the conclusion that massive solar distillation units were simply too expensive to compete with fuel-fired ones. Research has since focused on smaller solar distillation facilities.

38 facilities were developed in 14 nations between the 1960s and 1970s, with daily water capacity varying from a few hundred to 30,000 liters. Due to material failures, around one-third

of them have now been disassembled or abandoned. None of this size range are said to have been constructed in the last seven years.

2.5 PAST LITERATURE

Prof. Alpesh Mehta conducted study on solar still and discovered that output was at its peak in the late morning (between 11 and 1 o'clock) and that only 10% of the water entering the system was discharged. In other words, 20 liters of polluted water yield 2 liters of pure water. Pure water has a PH of 7, making it appropriate for human consumption (Tiwari & Dhiman, 1991).

IIT Guwahati scientists have already conducted research on solar water distillation. They mostly concentrate on modifying solar stills so that they may get the best output possible.

They concentrated on various variables that affected the operation and effectiveness of solar distillation units, such as solar intensity, wind speed, ambient temperature, water-glass temperature difference, free surface area of water, absorber plate area, temperature of inlet water, glass angle, and depth of water (Kumar & Tiwari, 1998).

A group of scholars in Hyderabad conduct research on solar water distillation. They focused primarily on the thermal energy mechanics of solar distillation. They made use of thermal or latent energy to maximize evaporation with no losses. They improved the solar still using nonmaterials like sponges and dyes (Chel, et al., 2009).

By fabricating solar stills, Amitava Bhattacharyya has conducted research on solar water distillation. He incorporates capillary tubes into his experiment as well. The thermal energy is trapped in the capillarity tubes, speeding up the evaporation process. The output rises in this process. He primarily concentrated on the use of constructed capillarity stills, which enable high water evaporation while requiring less heating and doing so in an economical manner (Shukla, et al., 2003).

Researchers from Jaipur have studied the solar water distillation technology. They focused primarily on the distillers' entire geometric structure. The solar radiation concentrator was added to the system. This provides the system with extra energy so that it can increase evaporation and reduce heat losses. The concentrated solar energy from the sun is directed to the water intake pipes, where it pre-heats polluted water before it is fed into the basin of the solar stills. This causes a significant increase in the efficiency of solar stills (Dimri, et al., 2008).

(Fath, 1998)reported a thorough analysis and technical evaluation of the various solar stills. Additionally highlighted were the changes in still setups, operational unit issues, and environmental effects. a discussion of the many techniques for raising the effectiveness of a single-basin passive solar still (Kalidasa Murugavel et al., 2008). The conclusions were as follows:

Double slope stills that are oriented south-north are preferable for low latitude locales.

An improved water condensation rate was achieved by optimizing the cover tiling angle.

With a black coated aluminum and a 2-centimeter water level, the efficiency of the still was increased by (28%).

Productivity varied according to the depth of the water and the capacity of the basin to hold heat.

Surface heating is improved when a Mica sheet is used as the absorber.

Mirrors are required to reflect sunlight into the basin from the still sidewalls.

(Arjunan et al., 2009)offered a thorough analysis and technical assessment of the various passive and active solar distillation systems used in India. These systems' categorisation was distilled. They pointed out that India's tremendous population growth, shifting lifestyles, and extreme demand for fresh water make water desalination there crucial. There was also a brief description of an economic analysis of solar stills. The results are summarized below.

- Reduced basin water capacity, varied water dye additions, increased absorptivity, collecting reflection radiation, and reduced heat loss all improved the performance of the solar still.
- Utilizing various active techniques, such as a flat-plate collector, heat exchanger, solar pond, solar heater, or other heating apparatuses, improved still performance.
- Still, production increased when the water ran over a glass cover at a consistent speed, when there was a large temperature difference between the water and the cover, and when the inlet water temperature was higher.
- By incorporating colors and warming the feeding water, water absorption was boosted.
- Aluminum sheet, black granite gravel, and black rubber were thought to be effective materials for increasing the heat capacity and absorptivity of the basin.

(Sampathkumar et al., 2010) presented A thorough analysis of the development of technology and thermal modeling of different active solar distillation systems. They came to the following conclusions after their discussions:

Controlling the water depth in the basin, basin material, wind speed, inlet water temperature, length of a solar still, solar radiation intensity, local climatic circumstances, insulation thickness, ambient temperature, and glass cover inclination angle all had an impact on the performance of an active solar still.

- The still cover was made of copper, which was an ideal material.
- The rate of water evaporation increased with the fall in glass temperature.

- Solar radiation intensity, total water output requirement, salt/saline water availability, cost of the still, ease of operation, maintenance costs, better utilization of available waste hot water, and useful lifetime of the solar still are the most crucial considerations.
- For basin liners, composite materials were suggested because of their propensity to improve thermal conductivity and productivity.

(Hanson, et al., 2004) examined the quality of solar still water in a specific basin. They discussed the effectiveness of a single-basin solar still in both a lab setting and a real-world field setting for the removal of a chosen collection of in-organic, bacterial, and organic pollutants.

(Akash et al., 2000) conducted experimental research on the effectiveness of a solar still with various cover glass inclination angles. They discovered that a 35-degree inclination angle produced the most water. (Al-Hinai et al., 2002) applied a mathematical model to calculate the productivity rate of a simple solar still under various climate conditions. They observed that the solar generates solar yield of 4.1 kg/m^2 per day under ideal design conditions in a year (Sahoo et al., 2008) designed a solar distiller of a basin(single) for fluoride extraction from drinking water. They found that using thermocol as insulation resulted in an 11% increase in efficiency, The distiller's efficiency rises by 4.69% when using a blackened absorber alone, against 6.05% when polystyrene insulation was added.

(Tanaka, 2009) examined the performance of a solar distiller basin that had reflectors internally and externally. Theoretical and experimental estimates of the daily productivity of still match well, especially on clear days. (Cooper, 1969) discovered that by installing interior and exterior reflectors could substantially increases the daily productivity by over seventy percent. Additional research on stills with internal and external reflectors was done by (Khalifa & Ibrahim, 2009). It was also proven by (Setoodeh et al., 2011) using a threedimensional two-phase model for a one-stage basin solar still as well as Dunkle's and the Kumar and Tiwari model were used to calculate the convective and evaporative heat transfer coefficients. (Kargar Sharif Abad et al., 2013) incorporated a solar still with a pulsed heat pipe (PHP). They discovered a significant increase in desalted water production, reaching a limit of 875 ml/m^2h or more. It has been discovered that tube solar collectors perform better than the conventional methods. An endeavor has been made to design and optimize a basin solar still, incorporating a magnetic treatment unit (0.12 Tesla) and a double glass cover with a water supply (Rehman Al-Hilphy& Rehman Saeed Al-Hilphy, 2013).

A multi-stage water desalination prototype was made by (Tigrine et al., 2015). Numerous experimental experiments have been undertaken to examine its performance. Higher distillation yields per unit area indicated considerable potential. A solar still with an exterior solar collector and a cooling water flow rate was created to boost productivity. To enhance vapor condensation, they used a double glass cover that allows cooling water to flow through. According to the experimental findings, the production rate is inversely correlated with solar radiation, air temperature and water flow rate used for cooling. The system could distill 0.4 liters per hour of low-salinity saline water (2–6 ppm), and the hot water could reach 87 °C(Mousa & Arabi, 2013).

The effectiveness of the collector system environment was investigated and evaluated by (Sheeba et al., 2015) utilizing both fresh-water as well as saline-water. The still basin, a flat plate collector's daily efficiency was found to be 20.4 and 23.6% greater than the still alone for fresh water and saline water systems, respectively.

(Khare et al., 2017) evaluated the impacts of different components used in the evaporator to boost the productivity of the solar still, including black rubber and black gravel. For water volumes of 5 liters,10liters and 15liters, they found that the solar still's efficiency was 32, 29, and 27%, respectively.

(Hassan & Abo-Elfadl, 2017) looked at how saline water and several condenser types. They asserted that utilizing a glass condenser with black steel fiber boosted daily production by up to 35% as compared to sand.

(Samuel Hansen & Kalidasa Murugavel, 2017) employed new absorber shapes (flat, grooved, and finely shaped) to boost the solar still's output and rate of evaporation. According to their findings, the integrated still with the fin-shaped absorber had a 40.9% increase in efficiency, which was 34.1% more than the enhanced efficiency of a normal inclined still with a flat absorber.

2.6 FUTURE MATERIAL ADVANCEMENTS

Productivity is impacted by the type of heat storage material and wick used in a still.

Paraffin wax and acetamide are two phase change materials (PCM) that show great promise for enhancing performance (Silakhori et al., 2013).

The world is moving toward a new nanoparticle revolution to enhance phase change materials' thermal qualities like thermal conductivity and heat transfer characteristics. Nano particles are already finding use in water treatment. In actuality, nanoparticles improve the thermal properties of water by expanding the area available for heat transfer. To fully utilize nanotechnology, a number of successful strategies and concepts have been put forth. In three different types of stills, black paint mixed with a nanomaterial was used (Sharshir et al., 2020). Both nano-ferric oxide and micro-ferric oxide were employed. A nano absorbent layer solar still had a maximum efficiency that was higher than a micro absorbent layer and a traditional solar still on both experimental days, with values of 68 and 55%, respectively, on the following days.

AL_2O_3-Therminol-55 was employed as a heat transfer nanofluid to speed up the solar collector loop's heat transfer rate. The performance of the improved active solar distillation system with a 53.55% efficiency obtained using nanoparticles at a concentration of 0.1% (Muraleedharan et al., 2019).

2.7 MATERIAL REQUIREMENTS IN SOLAR STILL FABRICATION

The fabrication of a solar still typically requires specific materials to ensure its effectiveness and durability. The materials selected should meet the following criterion:

- Materials should be economical to replace after degrading or have an extended shelf life in environmental conditions.
- They should be strong enough to withstand mild earth tremors and wind damage.
- Under intense temperatures, they shouldn't create vapor or give the water a bad taste. They also shouldn't be harmful. • Saline water and distilled water should not

be able to cause them to corrode.

- Their design has to be lightweight and of a size that make them easily transportable by means of transit.
- They ought to be manageable on the field.

2.8 BASIC COMPONENTS OF A SOLAR STILL

A still has the following basic parts:

1. The basin

2. Support structures
3. Glazing cover

The basin: In the basin, the brackish or saline water that will be subjected to distillation. It must therefore be waterproof and dark, ideally black, in order to better absorb sunlight and transform it into heat. In order to make cleaning any silt from it easier, it should also have a surface that is largely smooth.

Two varieties of basins exist. The first one is made of a shape-holding material that provides watertight confinement either by itself or in conjunction with a surface material that is applied directly to it. The second type defines the shape of the basin using a single set of materials (such wood or brick). A second material, acting as a waterproof liner, is then inserted into this, easily taking on the shape of the structural components. Not one construction material is suitable for every situation or location.

Support Structures: The glass cover is supported by supporting elements that also serve as the sides of the still and the basin. Wood, metal, concrete, or plastic are the main materials available for support structures. Most often, the choice of material depends on what is readily available in the area.

Glazing Cover: The glazing cover is the most important part of any solar still after the basin. It must be able to transmit a lot of visible light while preventing the heat produced by that light from exiting the basin because it is situated above the basin. A material must be able to survive the effects of UV radiation's deterioration or be affordable enough to be replaced on a regular basis. It may experience temperatures as high as 95°C (200F), so it must also be able to support its weight at those temperatures and avoid excessive expansion.

Ancillary components

Insulation, sealants, pipelines, valves, fittings, pumps, and water storage facilities are examples of ancillary parts. Typically, it is advisable to choose locally accessible, easily replaceable materials.

Insulation

Insulation slows down the heat transfer from a solar still, improving the still's efficiency. Since there is a lot of space under the still basin that could lose heat, insulation is typically added there.

Insulation can be achieved either by constructing the still on land that has dry soil and good drainage or the use of extruded Styrofoam or polyurethane.

Sealant

The sealant, is an essential to its proper functioning. It is used to hold the cover to the frame (support structure), keep the entire building airtight, and absorb variations in material expansion and contraction.

2.9 FACTORS INFLUENCING SOLAR STILL OPERATING PERFORMANCE

Performance of solar stills is affected by a number of variables. The factors that have the most influence include solar radiation intensity, collector area, basin water depth, and the temperature difference between the water and the glass cover plate.

Solar radiation intensity

(Badran & Abu-Khader, 2007) carried out a theoretical and experimental investigation on a single slope solar still based on the amount of solar radiation. They came to the conclusion that solar productivity and efficiency continue to rise with intensity. Early in the afternoon is when efficiency is at its highest because of the high solar radiation intensity at that time.

Temperature difference of glass cover plate and water

The production fluctuation at various temperatures was examined by (Kalidasa Murugavel et al., 2009) using an electrical resistance heater in a double slope solar still. They came to the conclusion that more distillate is produced when the temperature differential between the water and glass cover plate is high.

Collector area

According to (Velmurugan & Srithar, 2011), increased collector area boosts production. The productivity of the solar still improves with an increase in the free surface area of water in the basin because the evaporation rate of the water in the solar still is directly proportional to the exposure area (Alaudeen et al., 2014).

Thickness of glass cover plate

Glass has the ability to only permit shorter wavelength radiation to flow through while blocking longer wavelength radiation. This specific characteristic helps the solar still catch the majority of the incoming higher energy radiation but prevents it from radiating back. The glass acts as a condensing surface and has a lower temperature than the water within since it is exposed to the atmosphere. Three different solar stills with different glass cover plate thicknesses (3 mm, 5 mm, and 6 mm) were tested, the solar still with 3 mm thick glass cover plate resulted in higher production rate of 15.5%(Ghoneyem & Ileri, 1997).

Basin water depth

According to (Suneja & Tiwari, 1999), who examined the impact of water depth, a decrease in water depth boosts the production of the solar still.

At varied water depths, including 1 cm, 2.5 cm, 5 cm, and 7.5 cm, (Yan et al., 2012)experiment in a double slope solar still produced a maximum amount of distillate per day of 3.07 l/m^2 at 1cm water depth.

Wind velocity

The daily production of active and passive solar still increases with increasing wind speed up to a typical velocity beyond which the increase in production becomes minor, according to (ElSebaii, 2004)simulated study on the relationship between wind speed and daily productivity.

CHAPTER 3.

MATERIALS AND METHODS

3.1 CONCEPTUAL DESIGN

The design and selection of concepts for the Single Slope Solar Still were part of the current research project. A decision matrix was then used to compare the concepts. Graphics and schematics were used in the design of the most practical concept to display its working drawings. For the production, some locally sourced materials were purchased off the shelf and others were made from scraps. A functional prototype was created using simple workshop techniques, and it was later tested for effectiveness in operation.

3.1.1 Concept 1

Single slope solar stills with phase change materials (PCM)

The first concept involves the use of Phase Change Materials (PCMs) are essential components in solar water purification systems like single-slope solar stills. They function by taking advantage of a unique property: they change from one form (like a solid) to another (like a liquid) at a consistent temperature. During sunny periods when there's plenty of sunlight, PCMs absorb and save heat energy from the sun. Later, when there's less sun or it's nighttime, these PCMs gradually release the stored heat. In the context of solar stills, PCMs act like special thermal reservoirs, making sure the system maintains the right temperature for turning water into vapor and then back into liquid. This not only lets the solar still operate for longer periods but also makes it more energy-efficient, reducing the need for additional heating elements. As a result, it turns into a more economical and ecologically friendly method of purifying water, particularly in areas where water is scarce.

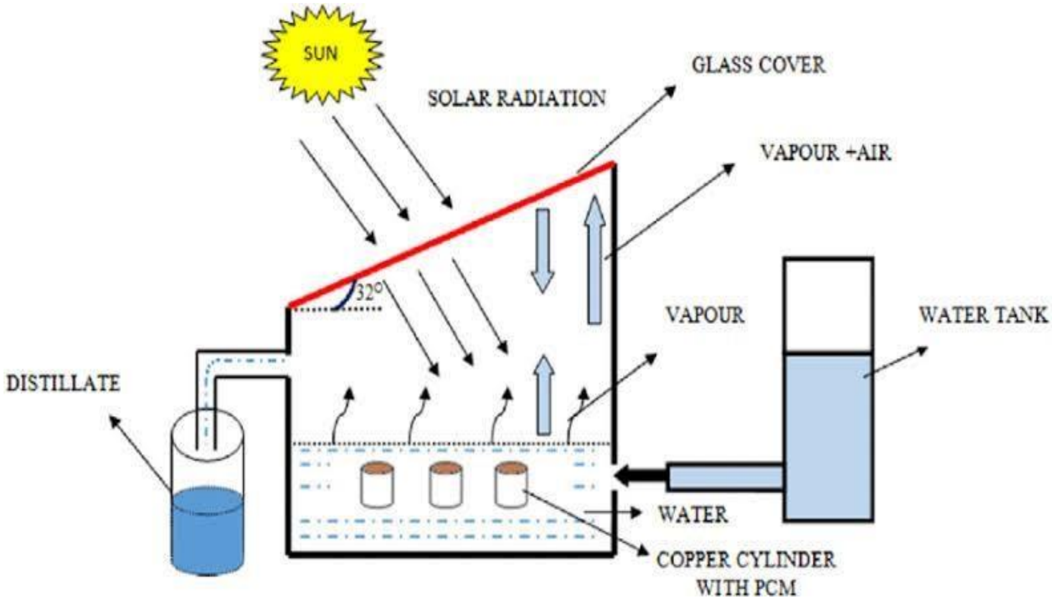


Fig 3.1 conceptual design 1

3.1.2 Concept 2

Single slope solar stills with an AC powered heating element

The second concept involves Using AC-powered heating elements in solar stills as it enhances performance by ensuring a consistent and controlled heat source. In a solar still setup, these heating elements are integrated to maintain a steady temperature in the basin of the still. This temperature control optimizes the process of water evaporation, ensuring that the water within the basin remains at the ideal temperature for efficient evaporation, even when there's limited sunlight. Moreover, AC heating elements enable the solar still to operate during nighttime or cloudy conditions, addressing the limitations of solar stills that rely solely on passive solar energy. However, it's important to note that using AC heating elements requires access to a reliable source of electricity, therefore factors such as energy efficiency and cost would be considered when implementing these systems.

The basic idea behind using AC-powered heating elements in solar stills is to maintain a stable and controllable heat source. By regulating the temperature within the still's basin, these elements improve the process of water evaporation, leading to better efficiency in distilling water and extending the hours during which the still can operate. This adaptability to different weather conditions and precise temperature control makes AC heating elements a valuable addition to solar still technology, especially in areas where sunlight and temperature conditions are variable.

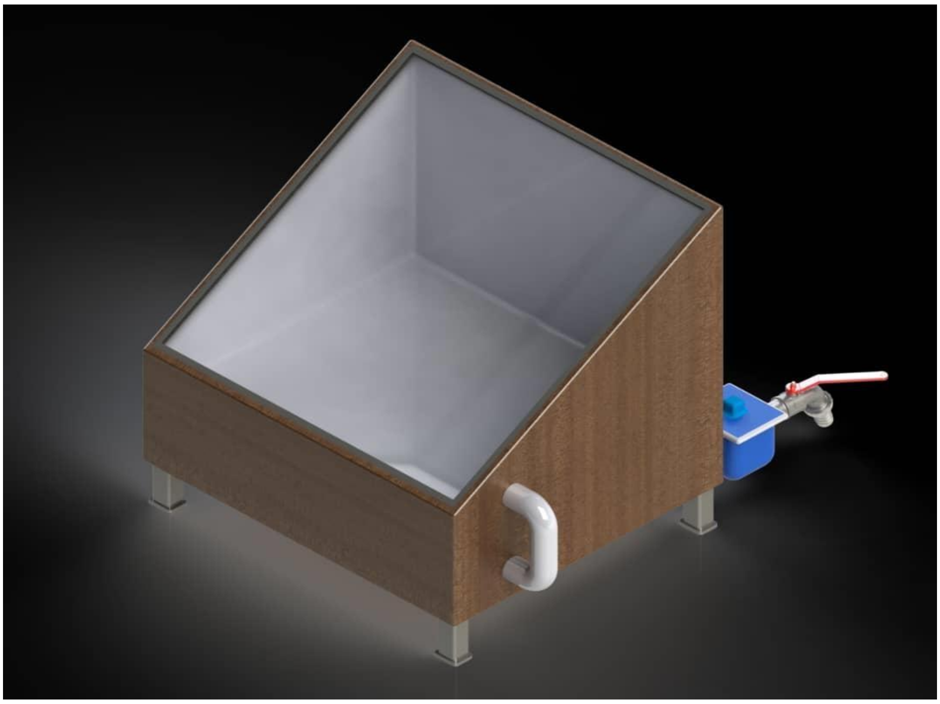


Fig 3.2 conceptual design 2

3.2 DECISION MATRIX

Using a decision matrix, a suitable concept was chosen from the two concepts that were reviewed. The weight criteria listed below were taken into account:

1. Energy efficiency – 0.15
2. Operational cost – 0.15
3. Output water quality – 0.2
4. Productivity – 0.3
5. Durability – 0.1

6. Ease of maintenance – 0.1

Table 3.1 Decision matrix table for solar still modification

Weighted Criteria	Weighting	Concept 1		Concept 2	
		Score	Total	Score	Total
Energy efficiency	0.15	9	1.35	6	0.9
Operational cost	0.15	8	1.2	7	1.05
Output water quality	0.2	7	1.4	9	1.8
Productivity	0.3	6	1.8	10	0.3
Durability	0.1	7	0.7	8	0.8
Ease of maintenance	0.1	7	0.7	8	0.8
Total			7.15		8.35

From the decision matrix in Table Concept 2 [single slope solar still with AC powered heating element] was chosen because Concept 1 had been selected based on total weighted criteria of 7.15, while Concept 2 had been selected based on total weighted criteria of 8.35.

3.3 MATERIAL SELECTION

Still basin

The Still basin It is the part of the system in which the water to be distilled is kept. The still basin is rectangular in shape. It can be made of materials such as rubber, asbestos cement, mild steel plate, reinforces plastic (RPF), polyethylene, fiber glass and wood.

It is necessary that the material for both the basin and the submerged absorber plate have high absorptivity or very less reflectivity and transmissivity. In this work, Stainless steel (Thermal conductivity = 15W/mK and specific heat capacity of 502.416 J/kgK) was used. Stainless steel was used because of its high corrosion resistance and durability. Aluminum, mild steel, Plastic, fiberglass and other materials may be used in place of stainless steel.

The volume of the still basin is obtained based on the required volume of water.

Therefore,

$V_{basin} = V_{water}$

$V_{basin} = l(0.8m) \times b\ (0.35m) \times h(0.24) = 0.0672\text{m}^3$

Hence, 0.0672 x 1000 = 67.2Litres

Side Walls

The Side walls are the part of the system that provides generally rigidity to the still system. Provides thermal resistance to the heat transfer that takes place from the system to the surrounding. The side wall can be circular, rectangular or a triangular. Wood was used for the construction of the side wall. Wood was selected because of its low thermal conductivity value of about 0.1-0.2 Wm/k. The inner layer of the side walls is coated with aluminum sheets to reflect 88% of light as well as painted white on the outside to reflect heat.

The Glazing Cover

The passage from where irradiation occurs on the surface of the basin is the top or glazing cover. Also, it is the surface that collects the condensate. It can be circular, rectangular or conical. A rectangular glazing cover which was inclined at an angle of 30^{o} was used. It can be made of materials such as tempered glass, ordinary glass, fiber glass and polyethylene.

However, an ordinary glass was selected here based on cost and market availability.

Channel

The channel started from one side of the basin and then protrudes outwardly from the other side of the basin.

The channel is the passage where the condensate formed which slid over the inner surface of the inclined glazing cover falls in and collects out the pure water. Polyvinyl chloride (PVC) pipes were used here as it is inexpensive to implement and provides a corrosion-free channel. It can also be made of materials such as galvanized iron and reinforce plastics.

Heating Elements

The heating element is used to increase the temperature of the basin (saline water). This increases the rate of evaporation and production of the distilled water. This can be well utilized when operating in low sunlight conditions.

They are mostly made from copper or stainless steel. They are wound into a spiral shape and placed in the basin of the solar still. The coils are connected to a power source and heated up and said heat is transferred to the basin/saline water causing it to evaporate.

Water storage unit for impure water

A water storage unit for impure water is an essential component of a solar still system. Its primary function is to act as a reservoir for collecting water from various sources, which may contain contaminants like dirt, minerals, microorganisms, and salts. Depending on local conditions and system needs, the unit may require preliminary treatment to eliminate larger particles and debris.

Water storage for pure water

Like the water storage unit for impure water, water storage for pure water is an essential component of a solar still system. Its primary function is to act as a reservoir for collecting condensed water vapor from the still basin, it is designed to be devoid of contaminants and dirt and is easily washable and cleanable. Depending on local conditions and system needs, the unit may require preliminary treatment for proper storage of water.

U.V Light

U.V (ultraviolet) light is known for its ability to disinfect water by inactivating bacteria and microorganisms. When the UV light is activated in the storage unit (water storage for pure water) it serves as an additional layer of protection against contaminants that may enter the water during storage.

Activated charcoal filter

Activated charcoal is known for its absorption properties, which means it can attract and trap the impurities in water, it helps to remove odors and taste in the water, the activated charcoal filter can also help in reducing microbial activities.

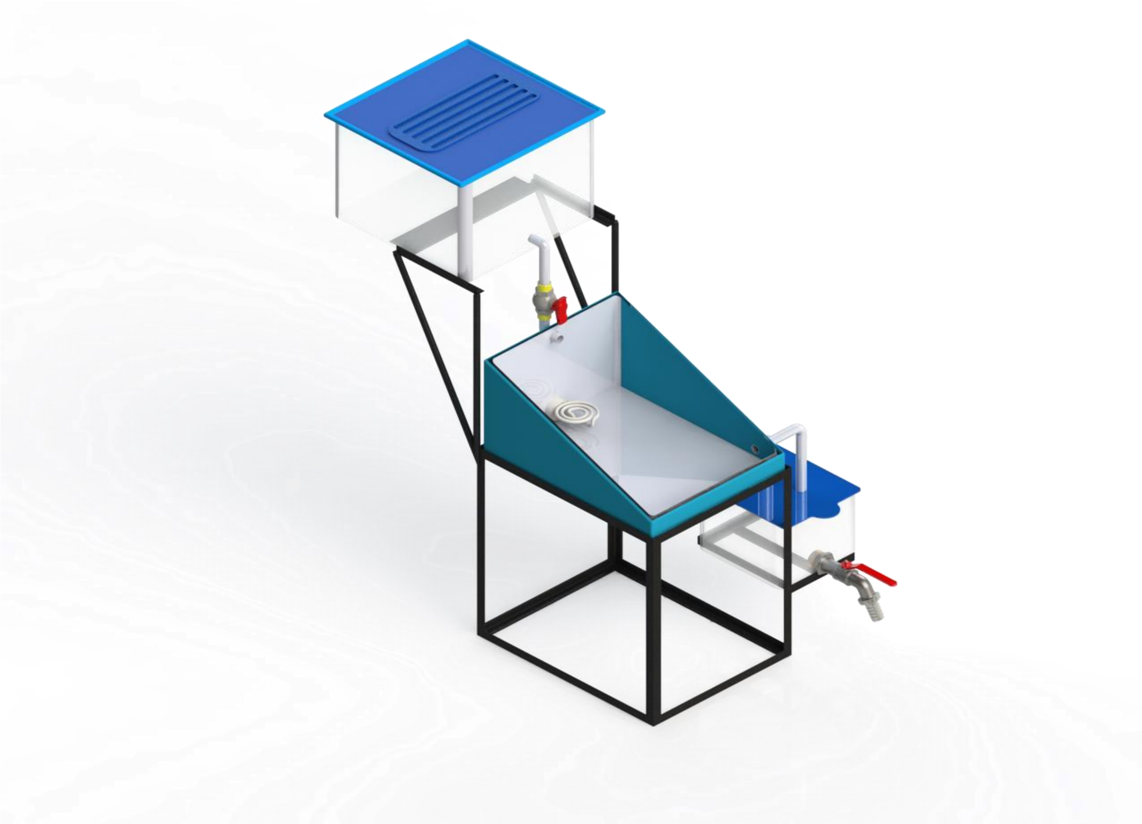
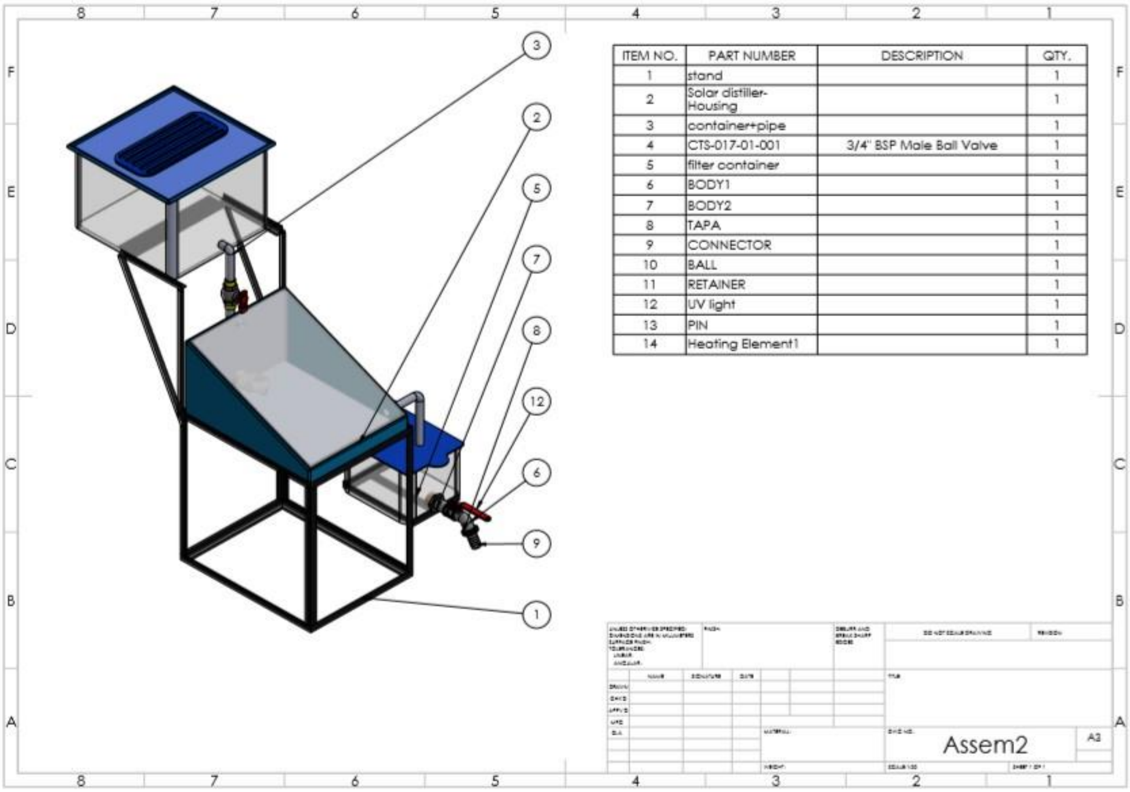


Fig 3.3 rendered image of our selected solar still concept



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	stand		1
2	Solar distiller-Housing		1
3	container+pipe		1
4	CTS-017-01-001	3/4" BSP Male Ball Valve	1
5	filter container		1
6	BODY1		1
7	BODY2		1
8	TAPA		1
9	CONNECTOR		1
10	BALL		1
11	RETAINER		1
12	UV light		1
13	PIN		1
14	Heating Element1		1

Fig 3.4 labelled schematics of selected solar still

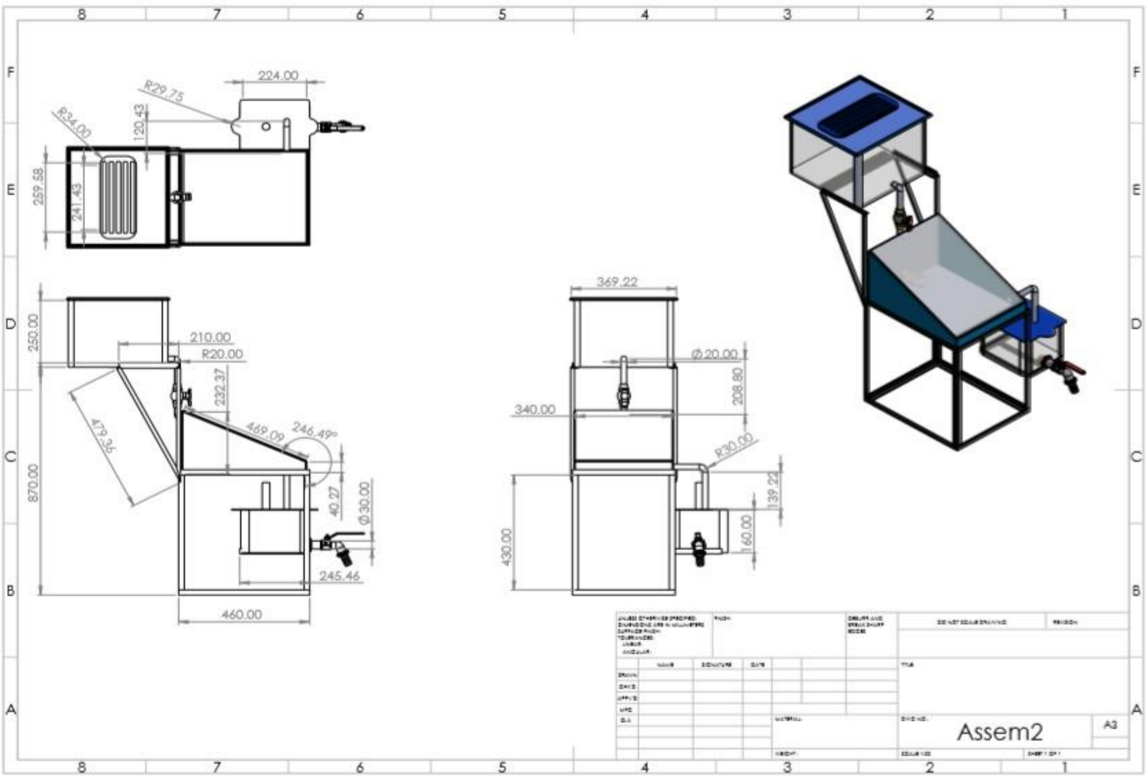


Fig 3.5 orthographic schematic of selected solar still

Fig 3.6 fabricated solar still

3.4 THEORETICAL FRAMEWORK AND THERMAL ANALYSIS OF SOLAR STILLS

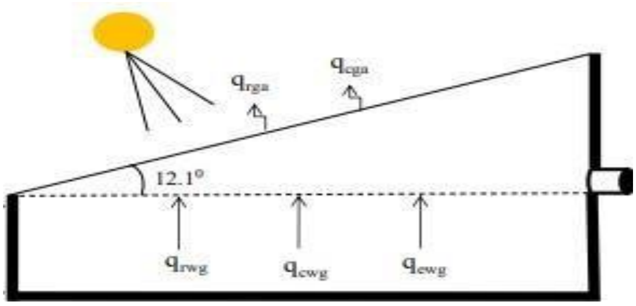


Fig 3.7 Schematic diagram of conventional solar still

The following heat energy equations govern the solar distillation process.

Solar Energy Equations of glass cover

$q_{lga} + C_{gdT_g} = I\alpha_g + q_{ewg} + q_{rwg} + q_{cwg}$

dt

Where $q_{lga} = (q_{cga} + q_{rga})$, is the heat loss through the glass surface to the ambient atmosphere. water evaporates to the glass cover through convection, and radiation, and to bottom through conduction, energy in the form of heat is lost to the confined air.

$I\alpha_w\tau = q_u + q_l$

Where $q_u = (C_w \frac{dT_w}{dt})$ is the usable heat rate, and $q_l (= q_{ewg} + q_{rwg} + q_{cwg} + q_b)$ is the total amount of heat lost from the water to the bottom and glass cover.

- q_r is the radiative
- q_c is the convective
- q_b is the evaporative
- $I\alpha_w\tau$ is the heat energy equivalent of the solar still basin

$$I\alpha_w\tau = q_{ewg} + q_{rwg} + q_{cwg} + q_b + C_w \frac{dT_w}{dt}$$

The heat energy balance of a single slope solar still is derived to be:

$$I\alpha_w\tau + I\alpha_g = q_{rga} + q_b + C_g \frac{dT_g}{dt} + C_w \frac{dT_w}{dt}$$

where α_g is the glass's absorbance. The following equation can be used to calculate the radiative heat transfer (q_{rwg}) from the water surface to the condensing cover:

$$q_{rwg} = h_{rwg}(T_w - T_g)$$

h_{rwg} is the coefficient of radiation heat transfer from the water surface to the glass and is calculated as follows:

$h_{rwg} = \varepsilon_f \sigma (\frac{T_w^4 - T_w^4}{T_w - T_g})$

ε_f is the effective emittance between the water surface and the glass cover and given by

$\varepsilon_f = (\frac{1}{\varepsilon_w} + \frac{1}{\varepsilon_g} - 1)$

It is possible to rewrite the radiation heat transfer from the surface of the water to the glass as

$q_{rwg} = F\sigma(T_w^4 - T_g^4)$

F is the shape factor σ is the Stefan –

Boltzmann constant

In a single slope solar still, the glass cover and basin surface are regarded as two parallel plates. As such the radiation heat transfer can be re-written as

$q_{rwg} = 0.9\sigma(T_w^4 - T_g^4)$

From the water surface to the glass cover of the still, the rate of heat loss via convection can be estimated.

$q_{cwg} = h_{cwg}(T_w - T_g)$

h_{cwg} is the convection heat transfer coefficient from water to glass.

(Dunkle, 1961) proposed an empirical relationship for the convective heat transfer coefficient, which is expressed by

$h_{cwg} = 0.884[T_w - T_g + 268 \overline{\quad\quad} (.9p\ wx - 10pg3-)\ p_w \mathrm{T_w}]\ ^{1/3}$

Pw and P_g are, respectively, the saturated partial pressures of water vapor in (N/m^2) at water temperature and glass temperature.

$P_w = \exp[25.31 - (\frac{5144}{T_w})]$

$P_g = \exp[25.31 - (\frac{5144}{T_g})]$

The evaporative heat loss (q_{ewg}) for water surface to glass cover can be gotten from

$q_{ewg} = h_{ewg} A_w (T_w - T_g)$

The evaporative heat transfer coefficient from water to glass cover is denoted by hwg and it is given by:

$h_{ewg} = 16.273x^{-3} h_{cwg} (\frac{p_w - p_g}{T_w - T_g})$

(Dunkle, 1961)proposed an empirical relationship for calculating evaporative heat loss, which is expressed by:

$q_{ewg} = 16.28 \times A_w h_{cwg} (P_w - P_g)$

It is possible to compute the convective heat loss from the glass cover to the surrounding air using

$q_{cga} = h_{cga} (T_g - T_a)$

$hcga$ is the glass and ambient air convective heat transfer coefficient and is given by h_{cga}

= 2.8 + 3.8V

V(m/s) is the wind speed q_{rga} is the heat loss by radiation from glass cover to sky

and can be calculated from

$q_{rga} = \varepsilon_g \sigma (T_g^4 - T_s^4)$

T_s is the radiant temperature of the sky.

Therefore, the total heat losses can be determined as the sum of

$(q_{cwg} + q_{ewg} + q_{rwg} + q_{cga} + q_{rga})$.

The total heat transfer coefficient from the water surface to the condensing cover can be calculated by adding the convection, radiation, and evaporative heat mass transfer coefficients within the distiller. It is provided by $h_1 = h_{cwg} + h_{ewg} + h_{rwg}$

Experimental efficiency

Solar stills' daily effectiveness can be calculated using

$$\eta \exp(d) = \frac{\sum m \, X \, L_w}{\sum I \, X \, A \, X \, t}$$

Where:

m – The daily total mass condensate collected

L_w - latent heat of water vaporization

I - Daily average radiation from the sun

A - glass cover area t – the collection

period

3.5 BILL OF MATERIALS

The bill of engineering materials for the single slope solar still with an AC heater is shown in Table 3.5-1

Table 3.2 Bill of engineering materials

S/N	COMPONENTS	QUANTITY	UNIT COST((₦)	TOTAL COST((₦)
1	Glass cover	1	8000	8000
2	Plastic Pipes	-	3000	3000
3	Wood	-	10000	10000
4	Activated Carbon filter	1	5500	5500
5	Heating Element	1	8000	8000
6	Mild Steel	-	15000	15000
7	Stainless steel	-	20000	20000
8	UV light	1	2500	2500
9	Ball Valves	1	6000	6000
10	Tap	1	3000	3000
11	Water Collectors 1	1	4000	4000
12	Water Collector 2	1	3000	3000
13	Labor	-	10,000	10,000
14	miscellaneous	-	10,000	20,000
	Total			108,000

3.6 TESTING PROCEDURE

The University of Benin's (UNIBEN) climate was utilized for the experimental test, in this experiment, a series of test is taken every hour from 8:00 to 6:00PM to determine the effect of solar intensity, wind speed and various environmental factors on the productivity of treatedwater by the solar still and a conclusion is to be derived on the effectiveness of the solar still in this specific region and period. The solar still's output was gathered and evaluated against the WHO's recommended limit for potable water. To determine how much our system purified the water, the water pre-treatment was also examined.

CHAPTER 4. RESULTS AND DISCUSSION

4.1 RESULTS

The daily productivity rate of CSS and MSS were taken at intervals and is presented in Tables 4.1-1 – 4.1-10

CSS – conventional solar still (single slope solar still)

MSS – modified solar still (single slope solar still augmented with an AC heater) *Table 4.1 CSS productivity performance day 1*

DAY 1: MONDAY		
Time(h)	Average daily solar radiation (W/m²)	productivity (normal)(ml)
8:00	165	5
9:00	265	15
10:00	378	70
11:00	444	100
12:00	523	157
13:00	644	280
14:00	710	320
15:00	679	380
16:00	453	210

17:00	289	187
18:00	110	78

Table 4.2 MSS productivity performance day 1

Time(h)	Average daily solar radiation (W/m²)	Energy produced by Heating Element(W)	Productivity (ml)
8:00	165	700	30
9:00	265	900	80
10:00	378	900	400
11:00	444	1100	784
12:00	523	1100	942
13:00	644	1200	1600
14:00	710	1500	1870
15:00	679	1200	1750
16:00	453	1500	2000
17:00	289	1500	2020
18:00	110	1500	1900

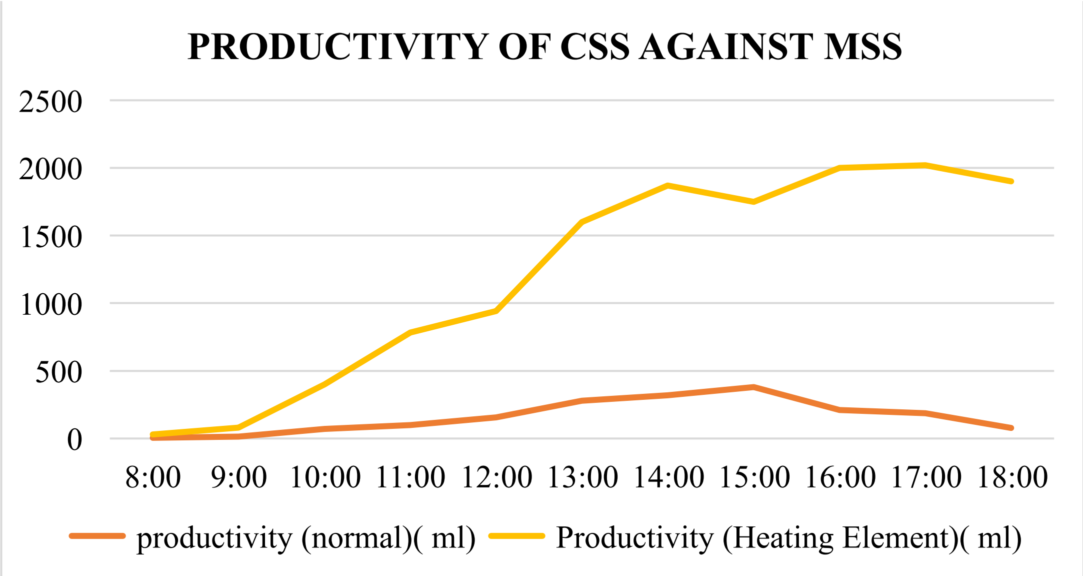


Fig 4.1 variation in productivity of CSS and MSS day 1

Table 4.3 CSS productivity performance day 2

DAY 2: TUESDAY		
Time(h)	Average daily solar radiation (W/m²)	productivity (normal)(ml)
8:00	140	4
9:00	249	13
10:00	345	63
11:00	436	98
12:00	589	143
13:00	628	286
14:00	689	421
15:00	679	390
16:00	423	201
17:00	323	170

18:00	150	66

Table 4.4 MSS productivity performance day 2

Time(h)	Average daily solar radiation (W/m²)	Energy produced by Heating Element(W)	Productivity (ml)
8:00	140	811	42
9:00	249	1024	93
10:00	345	1000	421
11:00	436	1199	832
12:00	589	1200	1000
13:00	628	1375	1712
14:00	689	1493	1923
15:00	679	1200	1850
16:00	423	1432	2100
17:00	323	1423	2219
18:00	150	1465	2100

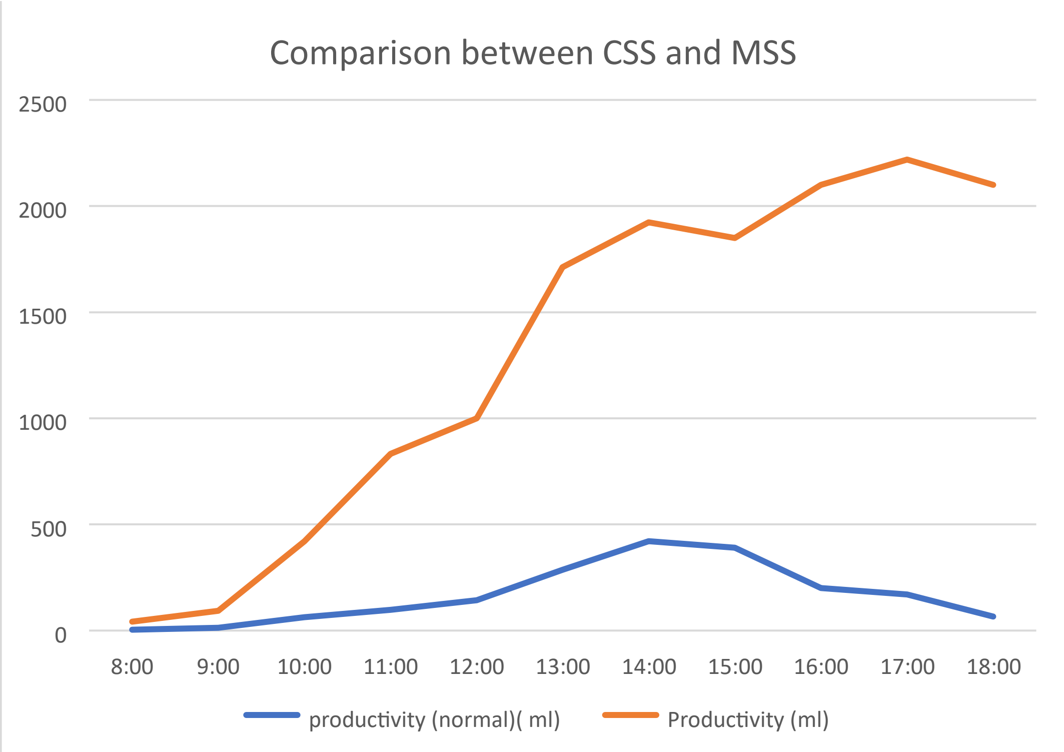


Fig 4.2 variation in productivity of CSS and MSS day 2

Table 4.5 CSS productivity performance day 3

DAY 3: WEDNESDAY		
Time(h)	Average daily solar radiation (W/m²)	productivity (normal)(ml)
8:00	183	7
9:00	290	18
10:00	400	72
11:00	485	102
12:00	576	185
13:00	666	302
14:00	780	500

15:00	679	429
16:00	483	700
17:00	345	230
18:00	232	100

Table 4.6 MSS productivity performance day 3

Time(h)	Average daily solar radiation (W/m²)		Productivity (ml)
8:00	183	811	63
9:00	290	1024	121
10:00	400	1000	586
11:00	485	1199	909
12:00	576	1200	1430
13:00	666	1375	2420
14:00	780	1493	4200
15:00	679	1200	4800
16:00	483	1432	5500
17:00	345	1423	5500
18:00	232	1465	5000

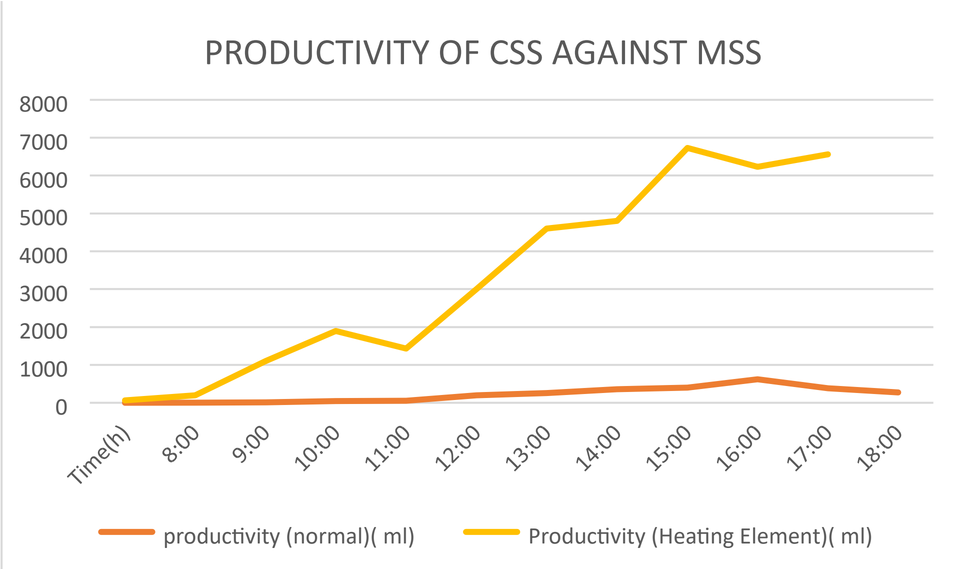


Fig 4.3 variation in productivity of CSS and MSS day 3

Table 4.7 CSS productivity performance day 4

DAY 4: THURSDAY		
Time(h)	Average daily solar radiation (W/m²)	productivity (normal)(ml)
8:00	90	3
9:00	179	9
10:00	230	45
11:00	320	55
12:00	400	200
13:00	445	253
14:00	559	354

15:00	438	400
16:00	298	620
17:00	265	387
18:00	180	273

Table 4.8 MSS productivity performance day 4

Time(h)	Average daily solar radiation (W/m²)	Energy produced by Heating Element(W)	Productivity (ml)
8:00	90	600	63
9:00	179	1100	200
10:00	230	1100	1100
11:00	320	1430	1900
12:00	400	1470	1430
13:00	445	1540	3000
14:00	559	1540	4600
15:00	438	1900	4800
16:00	298	2500	6730
17:00	365	2500	6230
18:00	180	2500	6560

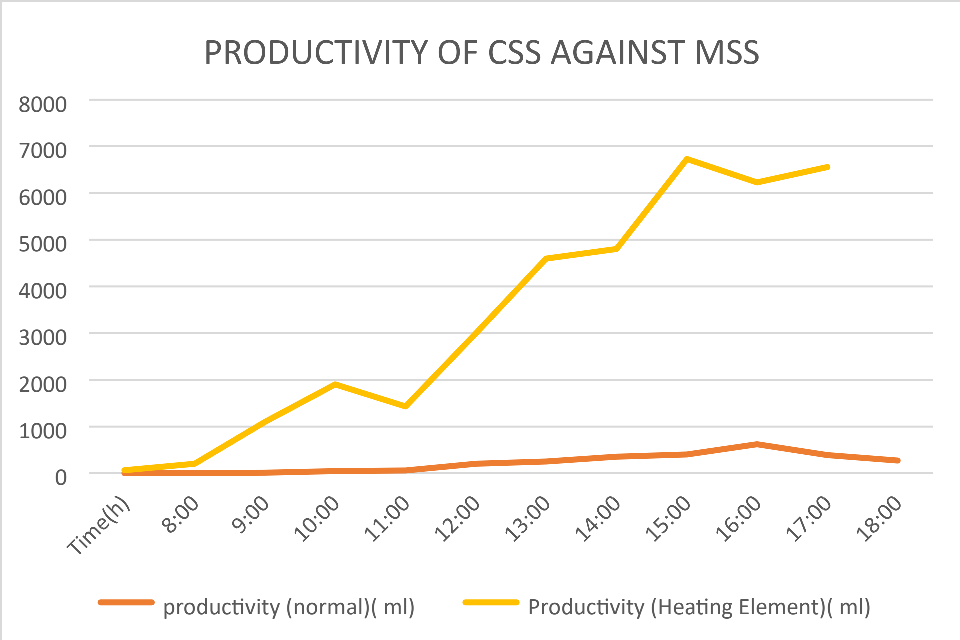


Fig 4.4 variation in productivity of CSS and MSS day 4

Table 4.9 CSS productivity performance day 5

DAY 5: FRIDAY		
Time(h)	Average daily solar radiation (W/m²)	productivity (normal)(ml)
8:00	203	8
9:00	313	24
10:00	423	80
11:00	498	120
12:00	567	190
13:00	609	323
14:00	776	529
15:00	643	439

16:00	497	720
17:00	319	280
18:00	231	160

Table 4.10 MSS productivity performance day 5

Time(h)	Average daily solar radiation (W/m²)	Energy produced by Heating Element(W)	Productivity (ml)
8:00	201	811	70
9:00	313	1024	140
10:00	423	1000	592
11:00	498	1199	919
12:00	567	1200	1456
13:00	609	1375	2432
14:00	776	1493	4282
15:00	643	1200	4653
16:00	497	1432	5330
17:00	319	1423	5200
18:00	231	1465	5350

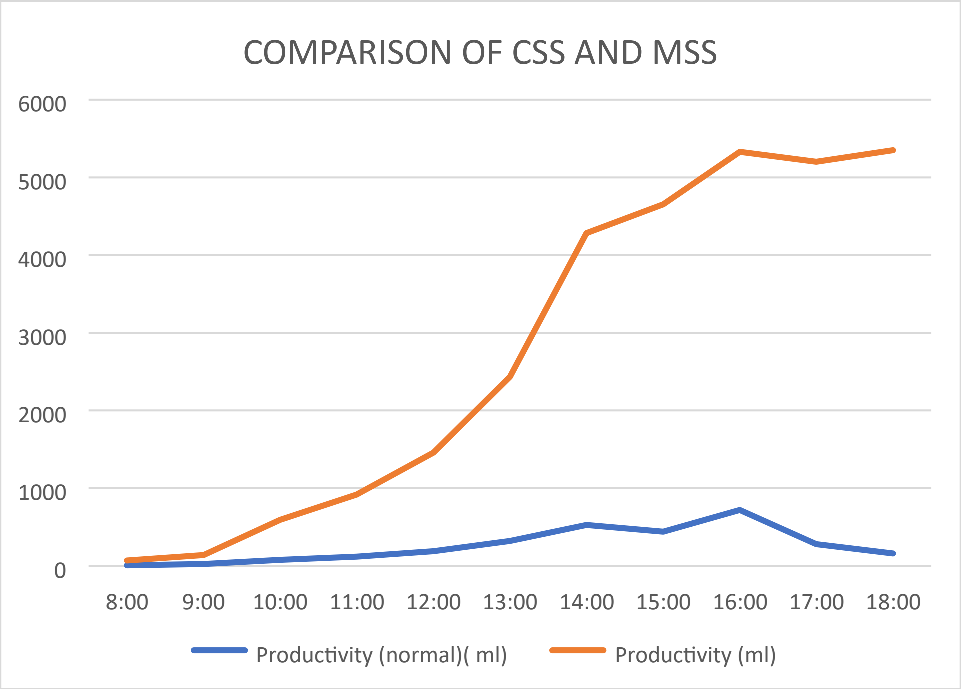


Fig 4.5 variation in productivity of CSS and MSS day 5

4.2 PURITY ANALYSIS

Following the 8am – 6pm analysis, the collected water is compared to a standard drinkable "potable Water" in accordance with WHO standards.

These tests were run in the UNIBEN lab, one of the chemistry department's labs.

Table 4.11 WHO standard of potable water against our water sample pre and post treated

Parameter	Pre-Treatment Sample	Post - Treatment Sample	Expected Limit
pH	5.92	6.9	6.5-8.5
conductivity (µscm³)	245.48	700	1000
suspended solid	10.56	5	3
turbidity (NTU)	10.56	7	5
Alkalinity	25	16	100
Chloride	15	14	100
Hardness	46.00	75	100
sulphate	11	9	100
calcium	2.5	2	75
Magnesium	3	3	20
Iron	1	0.38	0.3

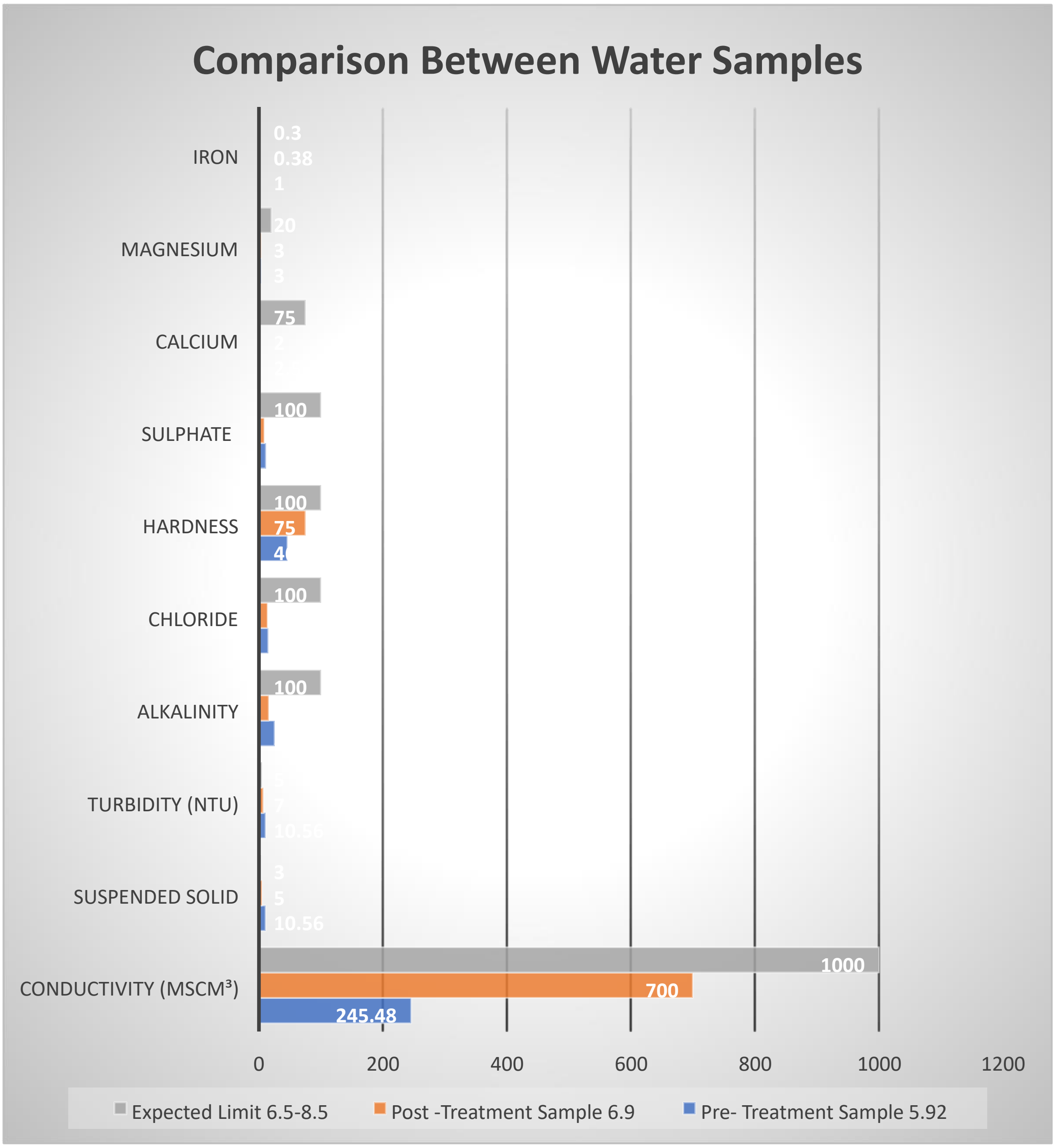


Fig 4.6 chart of purity test results

CHAPTER 5. CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The performance of home-scale solar water distillation using experimental data as well as the effects of the design parameters have been given and reviewed. It has been determined that a home-sized thermal distillation system is not fit as a roundabout way to distill water as the varying climate and temperatures in Nigeria affect its productivity rate and as assumed by the experiment should be assisted with extra heating equipment.

Although High productivity is correlated with high sun intensity, the extra stable heat source provided by the heating element goes a long way to lead to stable output in times of varying seasons.

The home-sized solar distillation system is a low-tech, reasonably priced option for producing fresh water in poor nations where portable water is short in quantity and quality and is required for drinking, sanitizing, and other domestic uses, although relying only on solar output is a varying element that could lead to high-low productivity at times, with the heating element the productivity is more quasi stable with about 6-10 times more than the conventional solar still. Though fluctuations in power and electricity problems of Nigeria affect constant productivity but it cannot be denied that it stands above the normal still in the marathon.

According to WHO guidelines, the water sample is generally safe to drink based on the purity analysis carried out.

The research's goal was accomplished, making it a major success.

5.2 RECOMMENDATIONS

During the experimental work of this project, a number of factors were discovered and if corrected, will improve the efficiency of the home size solar still. In view of this the following recommendations were made.

I. Sun tracking devices or thermal storage media can be utilized to increase the performance of the distillation system in places and times when solar radiation is low.

II. An opening should be provided for periodic flushing and cleaning of the solar distillation system basin.

III. A provision for the design of a condensation system to greatly improve the condensation rate of the water vapor produced by the still is advised.

These recommendations are to be looked upon and sought after as further improvisation of the project.

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