AN EXPERIMENTAL INVESTIGATION OF SOLAR STILL WITH ADDITION OF PHOTOCATALYST MATERIAL

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Abstract
In the current world scenario, electricity and drinking water are the most basic needs in human life. Industrialization and growth within the world's population have enlarged the demand for potable water. Water is obtainable in several forms like ocean water, surface water, underground water and atmospheric water. As freshwater resources are being rapidly ruined and polluted by humans, water shortages pose a great threat to the future. Distillation defines as thermal energy based process that mostly removes impurities from water. In this paper, water desalination experiments using solar energy with various photocatalysts were conducted. Renewable energy driven desalination is becoming more viable despite its expensive infrastructure because it employs free natural energy sources and releases no harmful effects to the environment. Potassium Permanganate ($KMnO_4$), Sodium Acetate ($C_2H_3NaO_2$) and Potassium Dichromate ($K_2Cr_2O_7$) were used as photocatalyst materials to improve productivity of solar still. Among used catalysts, the presence of Potassium Permanganate ($KMnO_4$) results in higher yield of fresh water than Sodium Acetate ($C_2H_3NaO_2$) and Potassium Dichromate ($K_2Cr_2O_7$). The freezing point of seawater decreases with increasing salt concentration. When solar radiation comes in contact with potassium dichromate, it makes organic materials less soluble. The main goal of this paper is to improve the water quality by building a solar water distillation system with different photocatalyst materials.
Index Terms: *Solar still, Photocatalysts, Desalination, Distillation, solar energy*

INTRODUCTION

Water is an elixir of life. Water is one of the precious gifts by the nature to mankind and we must save it for future generation. Water covers approximately three fourth of Earth's surface. Among water available on earth, about 97% is salty seawater and 2% is frozen in glaciers and polar ice caps. Thus, the remaining 1% of the world's water supply is a precious commodity which is necessary for our survival. Nowadays all over the world, many regions are in a bad situation of being short of fresh water, especially regions near the sea and islands where the seawater is abundant but cannot be directly utilized. The shortage of clean water for livelihood in many parts of the world is an important problem and requires immediate attention. The demand for fresh water is becoming an increasingly important issue across the world. In arid regions, potable water is very scarce and the establishment of a human habitat in these areas strongly depends on how much water can be made available.

In recent years, the advancing in the material processing and manufacturing is remarkable. One of the most industrial materials is the photocatalyst materials. The photocatalyst materials have the advantages of getting more yield than other materials. The productivity of solar still has been improved via different methods. Solar still is a device used in the solar distillation process to produce potable water. Desalination is a process which utilizes different forms of energy for separating seawater into two parts. The main water desalination or purification methods are the distillation, reverse osmosis and electro dialysis. Impurities free energies such as natural gas, solar thermal power and photovoltaic technology must be integrated with desalination technology.

The basic idea of a solar still is that salty or dirty water in an airtight container is heated by solar energy, causing it to evaporate. The water vapor then condenses on an inclined glass covering the surface, in order to allow fresh water to drain into a collection unit. Pure water evaporates and the impurities do not, distilling water and making it safe to drink. The solar still is represented as an energy storage system for water desalination. Therefore, the photocatalysts could be an effective addition to the solar still storage capacity. A solar photovoltaic powered solar still having daily yield 6 times more than the conventional solar still. Overall basin water temperature is 50% higher than the conventional solar still. The overall efficiency of a PV solar still is 35% more than the conventional solar still. In a combination of Photovoltaic thermal and ESM solar still, water in the basin and the ESM were heated by direct solar radiation and by hot water flowing through heat exchanger, fixed in the basin, heated by a solar collector. About 40% was water produced after sunset.

Active distillation and passive distillation are two different types of solar distillation system for getting potable water from seawater. Fresh water for small scale purposes like family then active distillation system is used. Active distillation system uses external sources to power root blowers, pumps and other instruments which uses for collection, storage and conversion of clean solar energy. External sources supplies heat energy along with solar radiation to water present in basin and pump helps fluid to circulate inside solar collectors. Air or liquid used as fluid in solar collectors of solar still. On other hand, passive distillation system works using direct sun light without external sources. As compare to active distillation system, passive distillation system gives lower yield. Nowadays, we are mainly focusing on clean energy or renewable energy so passive distillation system used at more places than active distillation system. As passive distillation system works on incident solar radiation, the temperature rise happens due to solar energy and it results into lower productivity of yield.

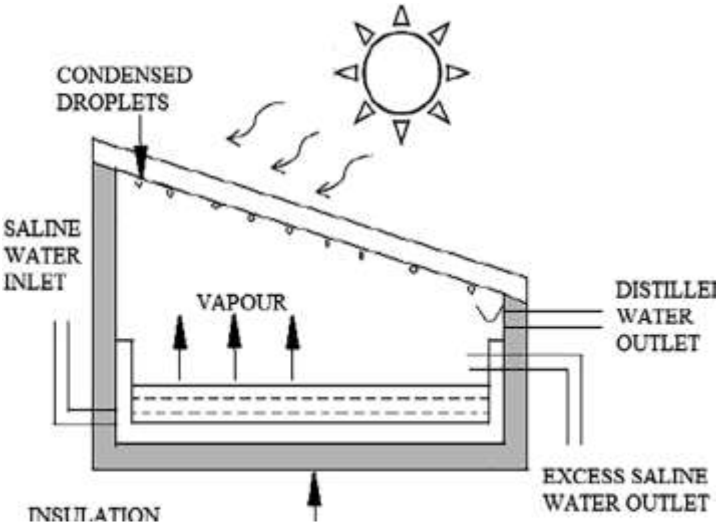

Figure1. Single Basin Solar Still

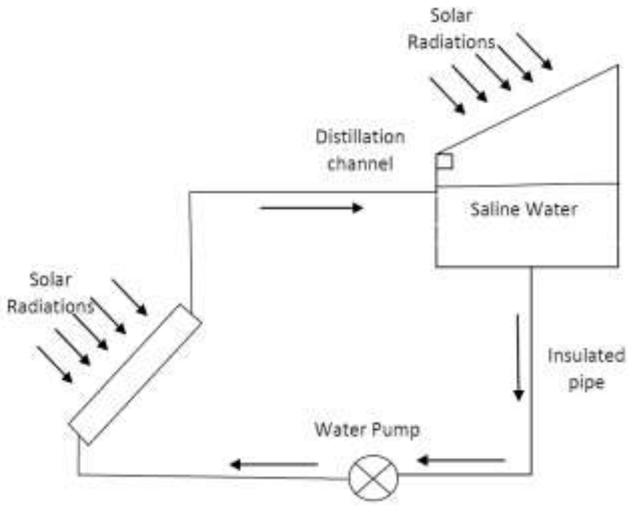

Figure2. Double Basin Solar Still

EXPERIMENTAL SET UP

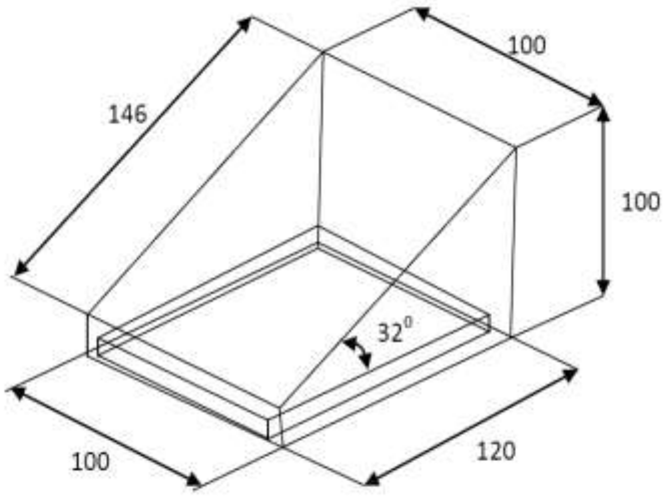

Figure3. Experimental Setup of Basin

The above figure shows single basin solar still having all dimensions in mm which is composed of top transparent glass, bottom transparent glass, and concentrator and sea water trough and device shell. Among them, the top transparent glass, the bottom transparent glass and the concentrator are together coiled into a sealed light concentration cavity. The gas in the concentration cavity is air. At the bottom of the seawater trough, there is a seawater inlet hole, and the bottom surface of the trough is coated with a black absorptive insulating layer, which is designed to reduce the heat conduction loss at the bottom of the seawater trough and promote the absorptivity to the solar radiation. Figure 3 shows a schematic of still using solar energy in this experimental approach. It consists of a stainless steel basin with an effective area of 1 m^2. This type of solar energy is still made of stainless steel, all measured in centimeters, as shown in Figure 3. The thickness of stainless steel sheet is 0.8mm. It consists of a transparent glass cover with a pitch of 32^0 and is coated with black paint to absorb the maximum possible solar energy. This lot still faces the direction of the South. The solar still are thermally insulated to prevent the heat loss through the side walls and the basin. Vapour leakage is prevented by sealant. The energy received from the sun should be kept inside the still to vaporize water. The materials used are saw dust, glass wool etc.

Water enters the basin through the inlet valve. In order to maintain a constant water level of 8 cm, the floater is used in the basin. Distilled water condenses on the inner surface of the glass lid and extends along its lower edge. The vapors which are generated inside the solar still is condensed on the inner surface of the transparent cover and water droplets move down words through the transparent cover. The fresh water is collected through the condensate channel fitted inside the solar still like in a bottle and measured by a graduated cylinder. Thermocouples are located at various locations on the site to measure temperatures, such as the outer glass cover, the inside of the glass cover, the pool water temperature, the steam temperature, and the ambient temperature. In this experiment, Potassium Dichromate ($K_2Cr_2O_7$), Sodium Acetate ($C_2H_3NaO_2$) and Potassium Permanganate ($KMnO_4$) were used as phase change materials. In order to improve the performance of solar distiller, all experimental work was conducted in Pune, India in February where solar incident radiation is more as compared to other months throughout a complete year. The melting point temperature of Potassium Permanganate (KMnO4) is 240^0C and Sodium Acetate is 324^0C.

RESULTS AND DISCUSSION

This experimental work conducted with Potassium Dichromate ($K_2Cr_2O_7$), Sodium Acetate ($C_2H_3NaO_2$) and Potassium Permanganate ($KMnO_4$) as photocatalyst materials to evaluate the performance of single basin solar still having stainless steel as a major base material. The performance of the developed solar distillation system has been evaluated by investigating the effects of the environmental and operational parameters on the productivity of the whole system.

The following graphs show the results obtained from experimentation done on solar still setup.

Figure 4 shows that solar radiation values for different ESM as the experimentation done with different ESM on different days.

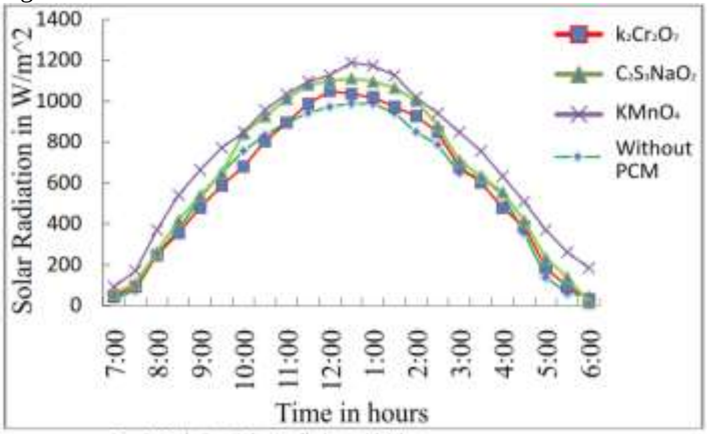

Fig 4: Variation Solar Radiation with Time

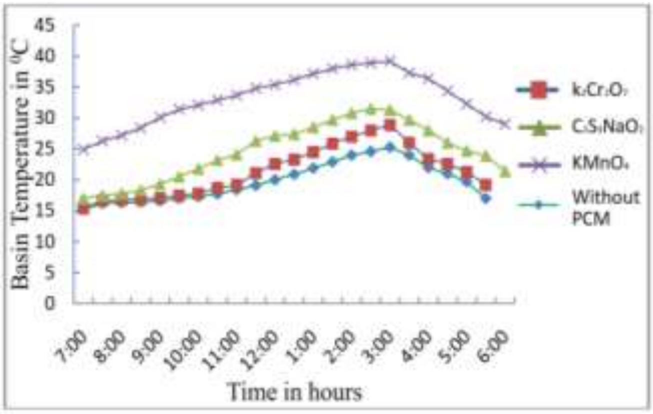

Fig 5: Variation of Basin Temperature with Time

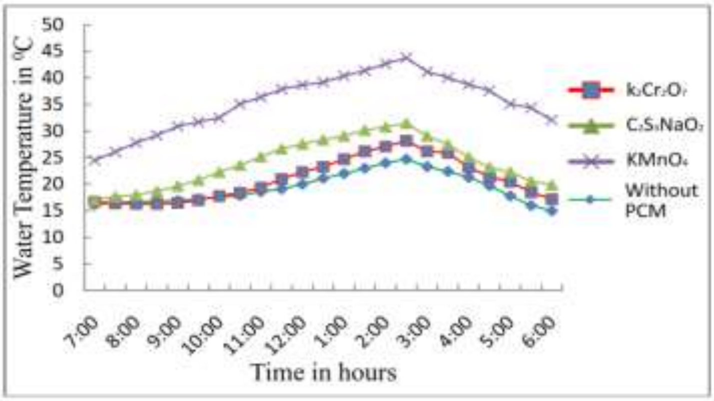

Fig 6: Variation Water Temperature with Time

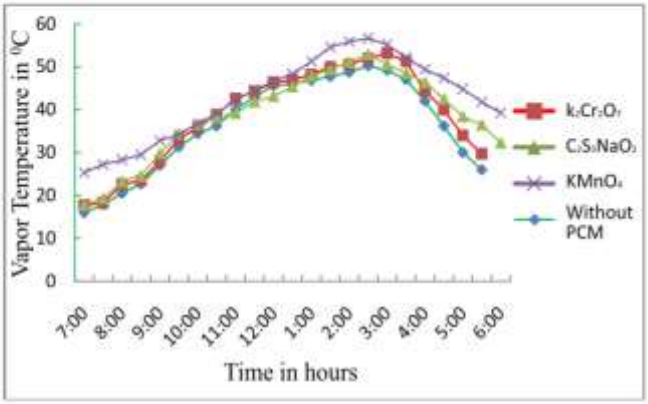

Fig 7: Variation of Vapour Temperature with Time

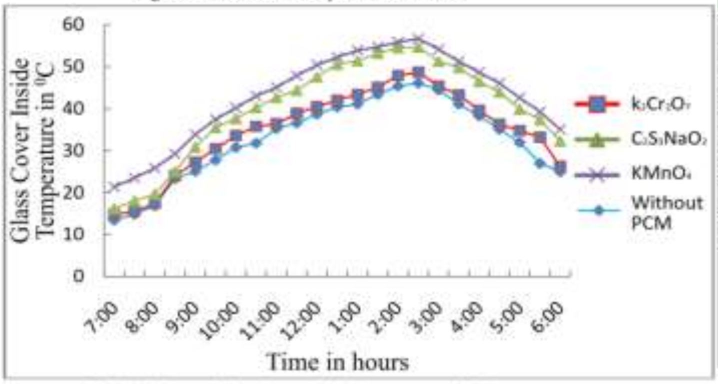

Fig 8: Variation of Glass Cover inside Temperature with Time

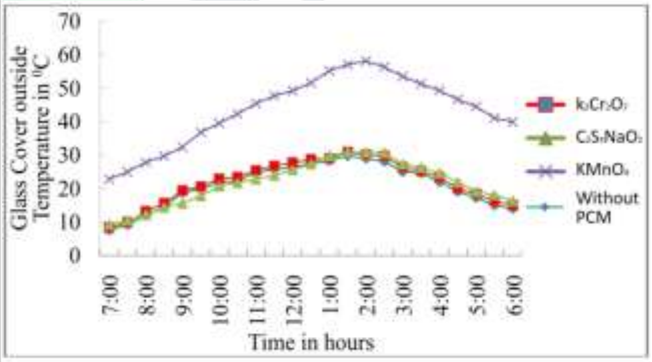

Fig 9: Variation of Glass Cover outside Temperature with Time

Figure 5, 6 and 7 shows the variation of basin temperature, water temperature and vapor temperature with time, basin temperature, water temperature and the vapor temperature of Potassium Permanganate (KMnO4) had highest values than Sodium acetate ($C_2H_3NaO_2$) and Potassium Dichromate ($K_2Cr_2O_7$). Vapor temperature of all photocatalyst materials showing less variation as compared to basin temperature and water temperature.

Figure 8 and 9 shows variation in inside and outside temperatures of Glass cover with time; it also demonstrated that Potassium Permanganate (KMnO4) had highest values than Sodium acetate ($C_2H_3NaO_2$) and Potassium Dichromate ($K_2Cr_2O_7$).

CONCLUSION AND FUTURE SCOPE

The amount of fresh or potable water is depends majorly on temperature difference between basin liner and inner glass surface if it increases then the productivity of yield increases and vice-versa. In present experimental study, the presence of Potassium Permanganate (KMnO4) in water could provide better yield when compared to that of Sodium acetate ($C_2H_3NaO_2$) and Potassium Dichromate ($K_2Cr_2O_7$) used as Photocatalyst Materials. Also it has been observed that higher yield obtained in modified still than conventional still. Units with photocatalyst materials give higher daytime productivity. The technology based on solar energy and its usage is very important and useful for developing and underdeveloped countries. Solar still is the best solution where solar radiation is more and external sources for getting potable water are very less.

Future work should be directed towards preheating the saline water, preheating the saline water at different temperatures, solar still with flat plate collectors and solar still with flat plate collector using different phase change materials. Current era will be focused on available renewable energy sources on earth as these resources will helpful to improve the efficiency of any equipment or system.

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