EXPERIMENTAL STUDY OF DESALINATION TECHNOLOGIES AND TIMER-BASED SOLAR PV TRACKING SYSTEM

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ABSTRACT

In this study the performance of solar desalination technology and timer based solar PV tracking system were analyzed. Solar energy has been used as an alternate source of energy for desalination. The performance of hexagonal basin dome type desalination unit has been studied. The experiments were conducted during the hottest months of the year i.e. May, June and July. The hexagonal basin dome type desalination unit was tested to investigate its performance in terms of the quantity of water distilled during the day and the quality of distilled water. It was observed that pH value was reduced from 9.1 to 6.2, total hardness reduced from 320 ppm to 38 ppm and TDS was reduced from 3640 ppm to 225 ppm which was much lower than standard/famous mineral water available in the market. In this study analysis of timer based solar PV tracking system was also conducted to provide maximum solar potential for the solar desalination. With this, the desalination unit produced distilled water at much lower cost than other types of solar equipment. Laboratory tests clearly show that the water after distillation could be used for any purpose. It was observed that this system is very simple, cost effective and also have capability to maintain the peak power of PV panel due to solar tracking system.

Keywords: *Solar desalination, Solar PV tracking, Hexagonal basin, Distillation, Desalination units*

1. INTRODUCTION

Pakistan is God gifted with renewable energy resources, such as hydel, solar, wind, geothermal and bio-mass. Hydropower source of energy is well known in Pakistan. The estimated hydro potential in Pakistan is about 50,000 MW. Up till now about 6595 MW has been developed. Small to medium size hydro power plants offer the greatest renewable energy potential for Pakistan. More importantly Pakistan geographically lies in highest solar insulation region in the world and has more than 300 clear days. The solar potential is estimated over 10,000 MW. Possibilities also exist in promoting greater use of wind, solar and biomass projects [1].

The wind potential is estimated up to 50,000 MW. Urban areas generate over 5500 tons of solid waste per day. About 56.9 million animals (buffaloes, cows) in Pakistan, can generate 21.35 million M^3 of biogas and 36.0 million tons of bio fertilizer per day. This indicates that Pakistan has huge potential of renewable energy resources [2].

1.1 APPLICATIONS OF SOLAR ENERGY

Solar distillation is a process, in which solar energy is trapped and used to evaporate impure or salty water. Water is life, among the basic need of food and air. Human beings have been dependent on rivers, lakes and underground reservoirs for acquiring fresh water. However, the pollution of rivers and lakes by industrial effluent and sewage has caused scarcity of fresh water in many towns and villages near lakes and rivers, so safe drinking water is an essential requirement for supporting life [3].

At various places, saline water is available in underground or in the oceans. This water can be distilled and made clean and safe from contaminants. Devices which produce potable water by utilizing solar heat energy, is called "solar water still". Distillation of saline water or brackish water is good method to obtain fresh and pure water. Distillation of saline water is an attractive method due to its simple technology [4].

Wide ranging applications are there of solar energy given by various researchers [5, 6], some of them are enlisted below:

- Solar water heating
- Solar air heater
- Solar space heating
- Solar distillation
- Heating of swimming pool by solar energy
- Solar pumping
- Solar cooking
- Solar furnaces
- Solar green houses
- Solar thermal power plants
- Solar photovoltaic system

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3. METHODOLOGY

3.1 HEXAGONAL TOMB SOLAR STILL

An experimental study was conducted on "Hexagonal Tomb Solar Still" fabricated in mechanical engineering workshop of the university by using indigenous material as shown in Figure No. 1. This solar still was tested to investigate its performance by considering various parameters like pH, TDS, E.C, and total hardness. The samples of water collected from different locations were used for desalination purpose and condensate was tested in laboratory.

The project timer based solar photovoltaic tracking system was fabricated in Energy and Environment Engineering Department of Quaid-e-Awam University of Engineering, Science and Technology. All the manufacturing process was carried out in Mechanical Engineering Workshop on the lathe machine such as (drilling, facing, threading, boring etc) and other process such as welding, polishing, cutting, assembly etc.

Fig. No. 1: Hexagonal Tomb Solar Still

3.2 SOLAR TRACKER

A solar tracker as shown in Figure No. 2 is a device for orienting a day lighting reflector, solar photovoltaic panel or concentrating solar reflector or lens toward the sun [8]. The sun's position in the sky varies both with the seasons and time of day as the sun moves across the sky. Solar powered equipment works best when pointed at the sun, so as solar tracker can increase the effectiveness of such equipment over any fixed position. There are many types of solar trackers, of varying costs, sophistication and performance. One well known type of solar tracker is the heliostat, a movable mirror that reflects the moving sun to a fixed location, but many other approaches are used [9, 10, 11].

Fig. No. 2: Solar tracker

3.3 TRACKER MOUNT TYPES

Solar trackers may be active or passive and may be single axis or dual axis. Single axis trackers usually use a polar mount for maximum solar efficiency. Single axis trackers usually have a manual elevation (axis tilt) adjustment on a second axis which is adjusted on regular intervals throughout the year. Compared to a fixed mount, a single axis tracker increases annual output by approximately 30% and a dual axis tracker an additional 6%. There are two types of dual axis trackers, polar and altitude azimuth [12].

The project "timer base photovoltaic solar tracking system" was designed, fabricated and tested in the Energy and Environment Engineering Department of Quaid-e-Awam University of Engineering, Science and Technology, Nawabshah. The project is placed on the roof of Energy and Environment Engineering Department and the observations and results were taken in the Energy Laboratory.

4. EXPERIMENTAL WORK

Three water samples A, B and C were collected. The parameters analyzed were pH, EC, TDS and total hardness. The analysis results of sample water obtained before the desalination process are given in table 1. The graphical presentation of analyzed result of each parameter is shown in Fig 3, Fig 4, Fig 5 and Fig 6.

TABLE 1: CHEMICAL COMPOSITION OF SAMPLE WATER BEFORE DESALINATION

Sample	pH	EC µs/cm	TDS (ppm)	Total hardness $CaCO_3$ mg/ltr
A	8.4	1.91	1337	269
B	9.1	5.20	3640	320
C	9.2	4.45	3115	263

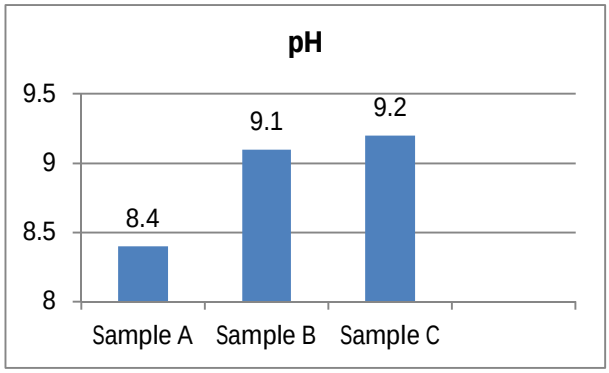

Fig 3: Graphical presentation of pH analyzed in water samples A, B and C

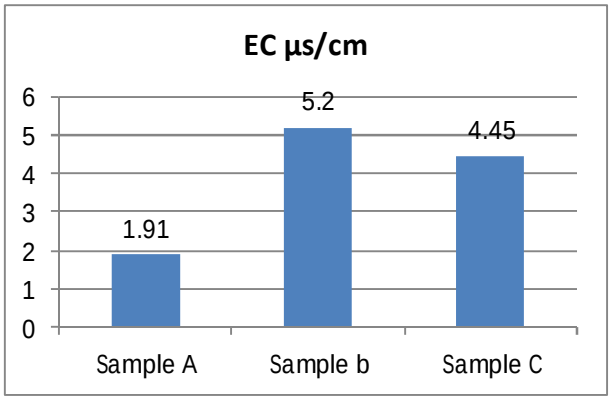

Fig 4: Graphical presentation of EC analyzed in water samples A, B and C

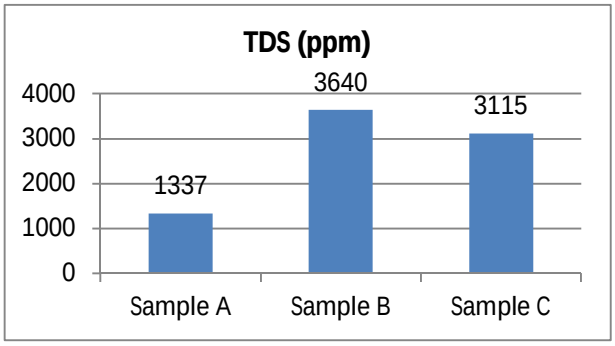

Fig 5: Graphical presentation of TDS analyzed in water samples A, B and C

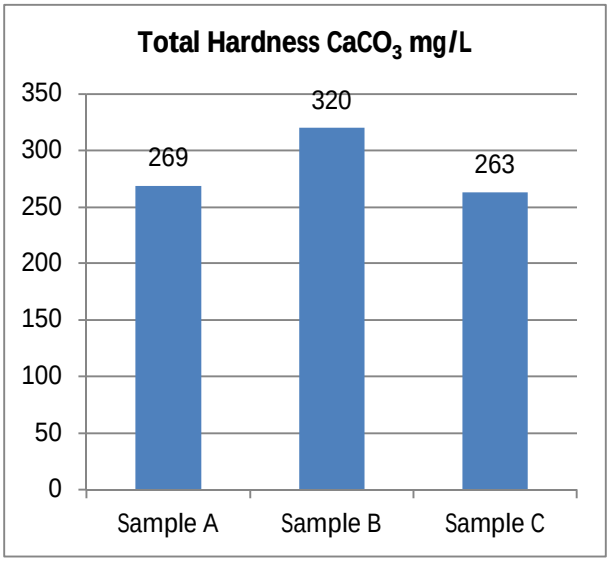

Fig 6: Graphical presentation of total hardness analyzed in water samples A, B and C

The collected water sample was processed through desalination process. After desalination process the water was analyzed again and the obtained results were compared with the previous results. The comparison of each parameter is given in table 2. The comparison is also represented in Fig. 7, Fig. 8 and Fig. 9. The reason of this decrease in levels of pH, E.C, TDS and Total Hardness is due to desalination process. With desalination process majority of impurities or pollutants are filtered or trapped and clean water is received.

TABLE 2: SAMPLE WATER PARAMETERS BEFORE AND AFTER DESALINATION

Parameter	**Before Desalination**	**After Desalination**
pH	9.1	6.1
E.C	5.20 µs/cm	0.31 µs/cm
TDS	3640 ppm	225 ppm
Total Hardness	320 mg/L	38 mg/L

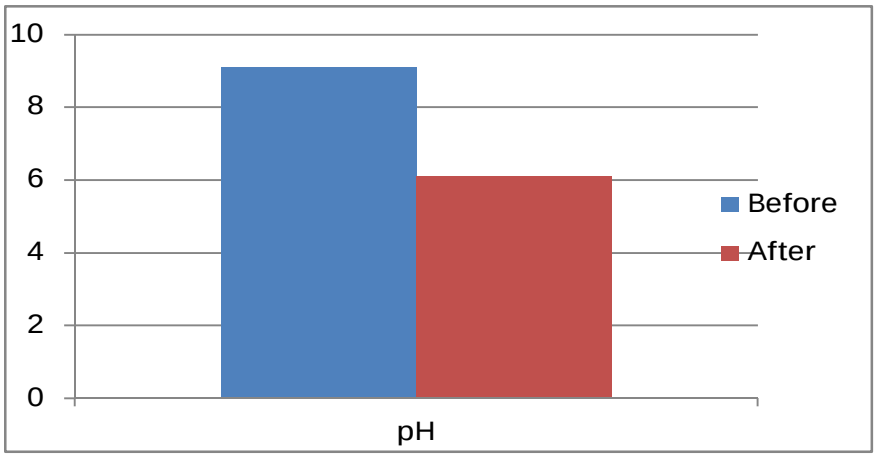

Fig. 7: Comparison of pH before and after Desalination

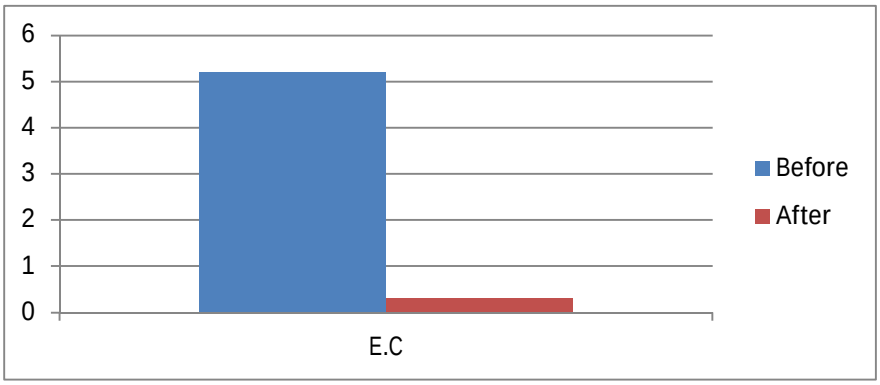

Fig. 8: Comparison of E.C (µs/cm) before and after Desalination

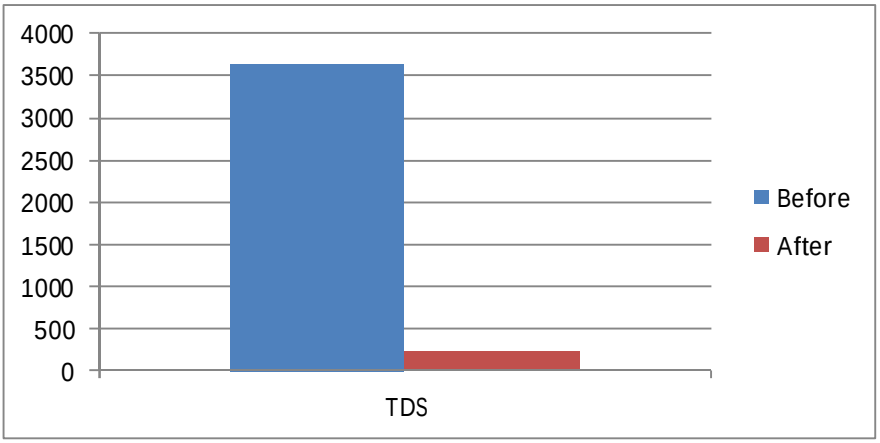

Fig 9: Comparison of TDS (ppm) before and after Desalination

In the end of research the comparison of desalinated water was also made with the mineral water brands. The results obtained are shown in table 3. The fig. 10 shows the comparison of these mineral water brands water quality and desalinated water.

TABLE 3: COMPARISON BETWEEN SOLAR STILL DISTILLED WATER AND BOTTLED MINERAL WATER

Parameter	SOLAR STILL	NESTLE	SUPER DEW DROPS
pH	6.1	6.5	7.0
E.C µs/cm	0.31	0.31	0.2
TDS ppm	225	162	120

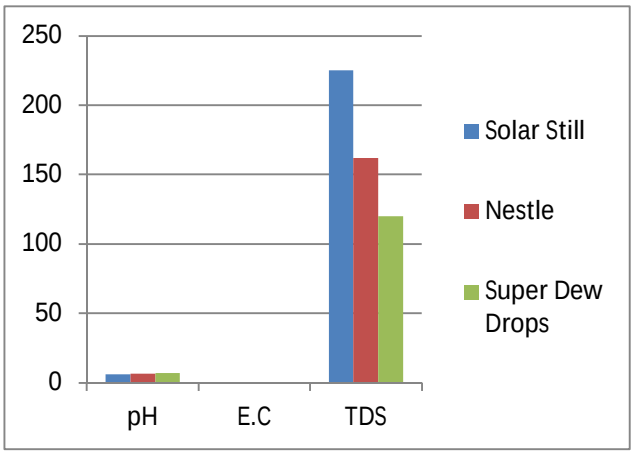

Fig. 10: Comparison of mineral water brands water quality and desalinated water.

TABLE 4: COMPARISON OF TIMER BASED SOLAR PHOTOVOLTAIC TRACKING SYSTEM WITH NON TRACKING SYSTEM

Load	Time Duration	PV Output						Battery Performance						Battery Charging			Battery Temp (°C)	
		Voltage (V)		Ampere (A)		Watt (W)		Voltage (V)		Ampere (A)		Watt (W)						
		W_0T*	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	W_0T	initial	W_0T	W_0T	W_0T	W_0T
Load-1	9:30	19.5	19.5	1.4	1.4	27.3	27.3	14.6	14.6	14.6	490	7154	7154	99	99	99	20	20
Load-2	9:40-10:02	19.1	19.1	1.6	1.7	30.56	32.47	13.5	13,5	13.5	490	6615	6615	99	99	99	21	20
Load-3	10:10-10:30	19.0	19.2	2.2	2.2	41.8	42.24	12.4	12.5	12.5	490	6076	6125	99	41	44	21	20
Load-4	11:06-11:26	18.6	19.2	2.6	2.7	48.36	51.84	11.4	11.6	11.6	490	5586	5684	99	15	19	26	23
Load-5	13:15-15:35	18.8	19.2	2.7	2.7	50.76	51.84	11.4	11.5	11.5	490	5586	5635	99	13	16	26	23

W_0T* = Without tracking system
W_0T = With tracking system
Load -1 = Without any load
Load -2 = Watt energy saver
load -3 = 2 energy saver of 11 watt and 18 watt
load-4 = Incandescent lamp of 100 watt
load-5 = 1 Incandescent lamp of 100 watt & 1 Energy saver of 11 watt

5. RESULT AND DISCUSSION

The research findings show that water is purified to the satisfactory level and comparable to the mineral water available in the market such as Nestle and Super Dew drops. The TDS was reduced from 3640 ppm to 225 ppm and pH value was reduced from 9.1 to 6.2. The hardness level of the distilled water was also reduced to the satisfactory level irrespective of the initial hardness. The overall performance of hexagonal solar still seems to be quite promising. Laboratory tests clearly show that the water after distillation could be used for any purpose.

In this research study the performance of solar desalination technologies and timer based Solar PV tracking system were analyzed. Solar energy has been used as the most prominent of alternate sources of energy for desalination. The performance of Hexagonal basin and Dome type desalination unit has been studied. The unit was tested to investigate its performance in terms of the quantity of water distilled during the day and the quality of distilled water. These desalination units have produced distilled water at a cost per unit of product lower than other types of solar equipment.

In this study analysis of timer based solar PV tracking system was also conducted. The results are shown in table 4. It was observed that this system is very simple, cost effective and also have capability to maintain the peak power of PV panel. This system was found useful

for increasing the charging of battery and maintained the battery temperature. It was found that by using this tracking system the output/efficiency of PV panel and life of battery was also increased.

6. CONCLUSION

The hexagonal basin type solar still has produced distilled water which turns potable as evident from the obtained test results at a cost per unit of product lower than other types of solar equipment. The priority water quality parameters like pH, TDS, E.C and total hardness are decreased up to the permissible level. The model of timer based solar tracking system further enhances the potential of desalination.

It was found that timer based solar tracking system has better efficiency than without tracking system or stationary photovoltaic system. The time and angle of the sun can easily be set from this simple method. It is also observed that by using timer based solar tracking system the battery is frequently charged than that in the stationary photovoltaic panel. By using timer based solar tracking system, the battery temperature was also decreased than that of stationary photovoltaic panel.

In remote areas, where potable water is rare or not available, solar still can provide one of the possible solutions of this problem of potable water. Solar desalination units are technologically the simplest systems today.

7. ACKNOWLEDGEMENT

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