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Effect of Climate Parameter on Solar Still: A Concise Review

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***Abstract:* -** Conventional solar still have poor efficiency and low distillate output. Climate parameter play important role in efficiency of solar still. Many investigators have investigated the effect of climate parameter to improve the performance of solar still. This review paper evaluates the effect of several climate parameters like wind velocity, ambient temperature, location and vapour pressure. Review was to be done to minimize adverse effect of climate parameter to improve the performance solar still. From this review, it is found that productivity of still increase with increasing wind speed but performance of still little bit decrease with higher wind velocity approximately more than 9 m/s. There is direct relationship between the solar radiation and ambient temperature. The daily productivity increased as ambient temperature increased and directly promotional to the solar radiation. The productivity remains intact during the variation in vapour pressure of surrounding air on solar still. Further, it is found that at low latitude station in India, yearly total radiation and seasonally radiation are approximately equal irrespective of E-W or N-S orientation for double slop single basin solar still. At high latitude, the east-west orientation receives more radiation than the south-north orientation, taking the year as a whole, while there is no effect of orientation in case of lower latitude for double slope single basin solar still. The single slope solar still single basin facing south collects greater amount of solar radiation as compared to the dual slope single basin solar still at lower and higher latitude locations. Solar still would be kept south facing for northern latitude and north facing for southern latitude.

Keywords: Desalination, Solar Still, Climate Parameter.

I. Introduction

One of the most vital ingredients for human nourishment is water. It is extensively utilized for domestic tasks like cooking and soon, irrigation, and agriculture. The biggest health risk in the modern world is access to fresh water. Less than 1% of the fresh water on Earth is accessible to humans, 2% is present as icebergs and glaciers whereas over two-thirds of the planet's surface is covered in water, of which over 97% is salty. The fresh water resources that are fixed on the surface of the earth are currently running out considerably more quickly due to pollution and population growth brought on by industrial expansion, transportation, etc. [1]. The ratio of water withdrawal to water availability was characterized as the water stress index (WSI). This indicator is a good way to show the disparity between the amount of water available and the total amount of water used by humans in a given area over a certain amount of time [2]. In order to identify the primary driver of changes in water scarcity, the effects of climate change and human activity on variations in water withdrawal and availability were also divided [2]. Figure 1 showed that conditions related to water scarcity worsened in the majority of regions, and in some water-scarce hotspots, such as Mexico, Sub-Saharan Africa, the Middle East, India, Central Asia, and northern China, where WSI rose by more than 40% between 1991 and 2010 compared to 1971–1990.

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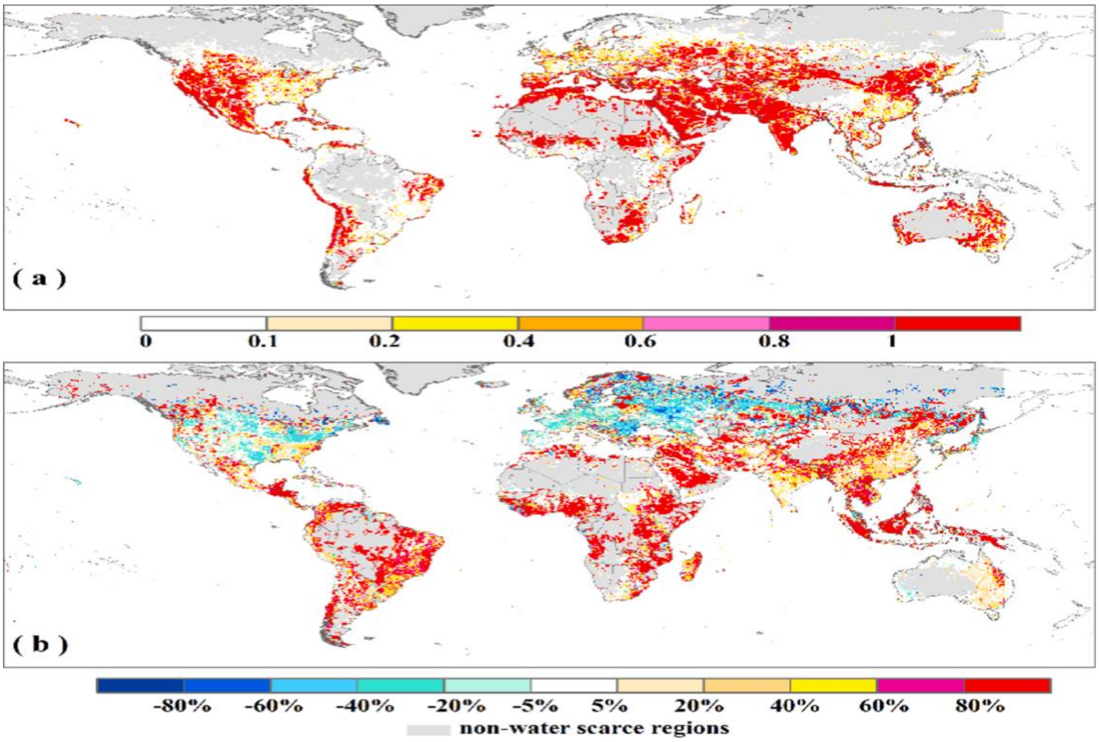

Figure 1. The Spatial Distribution of Global Water Scarcity Conditions and Their Changing Patterns: (A) The Spatial Distribution of Long-Term Average of Global Water Stress Index (WSI) During 1971–2010 and (B) Relative Change of Long-Term Average of WSI During 1991–2010 Compared To 1971–1990 [2].

Water can be classified as per ppm norms and based on the use. The first water category (grade) is designed for various industrial uses, home uses, and safe drinking. The salinity range for this type of water is 5 to 1000 ppm [3]. This kind of water is produced by industrial desalination operations and can be found in rivers and lakes. Various range of salinity water used in large cities. Water with a salinity of less than 150 parts per million is used for drinking in large cities, whereas water with a salinity of up to 1000 parts per million is utilized for various domestic purposes. The salinity range for the second water category is 1000–3000 ppm. This kind of water is appropriate for industrial cooling and irrigation. Brackish and sea water called as higher saline water [3]. For brackish water, the salinity range is 3000–10,000 ppm. The average salinity of seawater is 34,000 parts per million. Water is called high salinity water which has a salinity of more than 10,000 parts per million [3]. Seawater typically has a total salinity of 36000 ppm, as seen in Table 1. Seawater contains a wide range of fine suspended particles, such as sand, clay, bacteria, viruses, and colloidal debris, in addition to dissolved ions. These molecules or compound vary in size between $5\times l0^{-2}$ and 0.15 μm [3].

Table 1 Typical Composition of Seawater with Salinity of 36,000 ppm [3].

Compound	Composition	Mass Percent	ppm
Chloride	Cl^-	55.03	19810.8
Sodium	Na^+	30.61	11019.6
sulfate	$(SO_4)^{--}$	7.68	2764.8
Magnesium	Mg^{++}	3.69	1328.4
Calcium	Ca^{++}	1.16	417.6
Potassium	K^+	1.16	417.6
Carbonic Acid	$(CO_3)^{--}$	0.41	147.6
Bromine	Br^-	0.19	68.4
Boric Acid	$H_3BO_3^-$	0.07	25.2
Strontium	Sr^{++}	0.04	14.4
Total		100	36000

The presence of viruses, bacteria, parasitic organisms, liquefied and unidentified substances, physical and chemical pollutants, and other contaminants in contaminated water can seriously harm to human hygiene. Therefore, the water available from the various aquatic sources (such as rivers, lakes, oceans, rain etc.) has to be refined [4]. Unknowingly consuming contaminated water causes cholera, chronic diarrhea, dysentery, hepatitis A, typhoid, and polio, among other acute and chronic illnesses in large numbers of people.

The scarcity of clean freshwater is at a critical stage today in several countries. Scarcity of fresh water problems has been facing in many arid zones of Gujarat, Madhyapradesh and Rajasthan. Small fisherman does not have enough space to carry fresh water along with in ship as space is required to fill sea water fish and product. Gulf of Kutch and Khambhat produce high quality salt and delivers to world. This place also faced problem of scarcity of fresh and healthy water This type of crisis adversely affects in fishing industries and salt manufacturing which are essential for human survival and development in Gujarat.

Reference [3] defined that the industrial desalination processes involve the separation of nearly salt-free fresh water from sea or brackish water, where the salts are concentrated in the rejected brine stream. It is explained here in Figure 2.

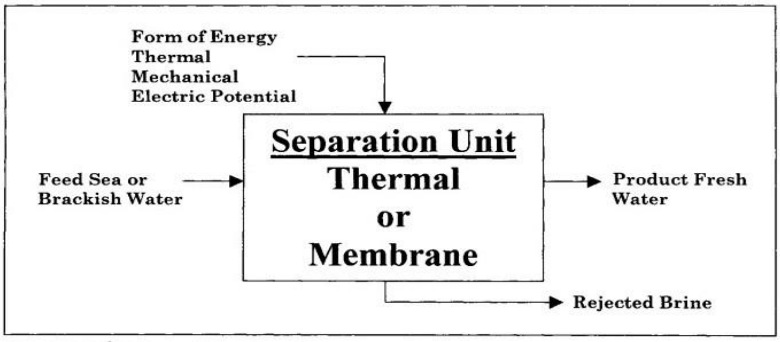

Figure 2. Desalination Process [3].

Reference [3] classified the desalination processes on base of thermal or membrane separation methods.

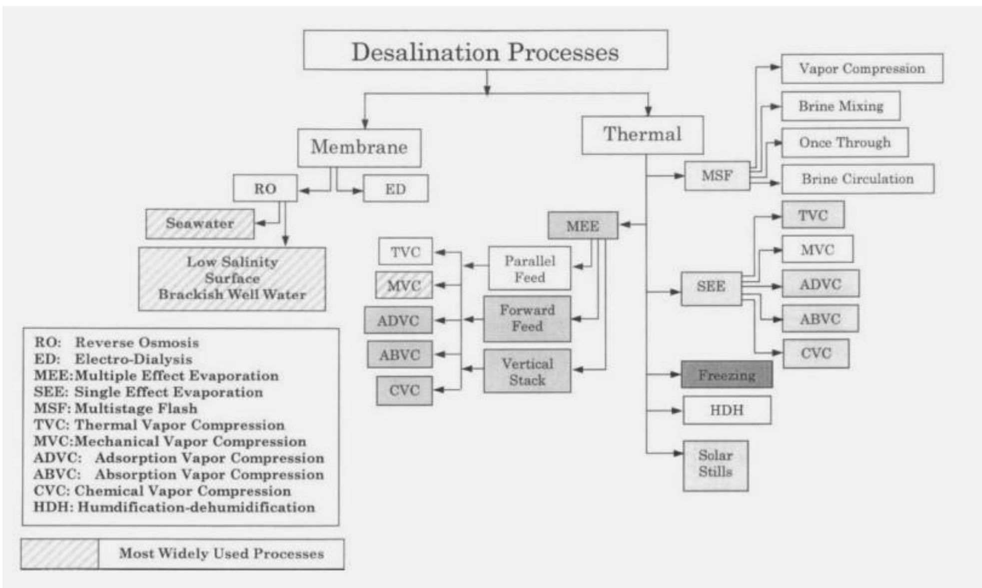

Figure 3. Thermal and Membrane Desalination Process [3].

The desalination processes can also be classified according to the type of main energy form of energy used to drive the process [3]. This classification is shown in Figure 4.

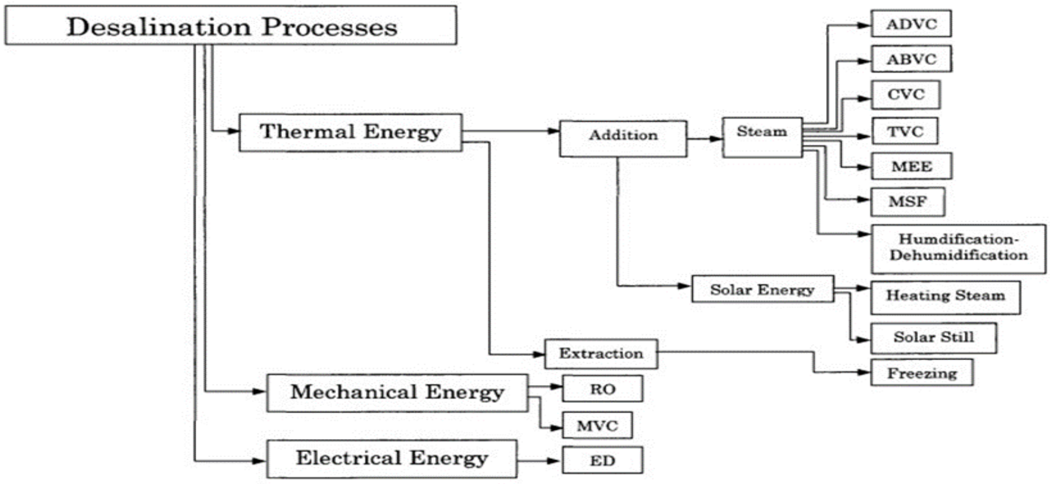

Figure 4. Energy Classification of Desalination Process [3].

The thermal energy processes are separated into two groups, where energy is either added or lost, as Figure 4 illustrates. The MSF, MEE, HDH, are energy adding process and processes are fulfilled with thermal, chemical, adsorption, or absorption heat pumps. Solar energy, a specialized boiler unit, or a cogeneration power plant can supply the heating steam needed for these operations and can be used in desalination process. Desalination through energy removal includes the freezing process. Under the category of mechanical energy desalination are the RO and MVC systems. Water passes through the membrane and salt is retained in the brine stream during the reverse osmosis (RO) process. Mechanical energy or the pressure differential across the membrane are used for this process. As for the MVC process, the compressor and evaporator form one single unit. The mechanical energy of the vapor compressor increases the pressure and temperature of the distillate vapour and converted into superheat steam which is condensed in tube and converted distilled water. During condensation loss of heat is used to heat the feed seawater. The last category shown in Figure 4 is on base of electrical energy. Electrical energy is utilized to separate water and salt. This is the electro-dialysis process, where the electric energy drives the electrically charged ions through selective membranes.

Numerous methods, including Reverse Osmosis (RO), Vacuum Distillation, Vapour Compression (VC), Multi Effect Distillation (MED), and Multi Stage Flash Distillation (MSF), have been used to purify water [5]. The water purification processes of reverse osmosis (RO), vapour compression (VC), and electro-dialysis (ED) are very energy- and money-intensive. It is commonly recognized that desalination facilities rely on conventional fuels and require electrical energy, which has negative effects on the environment and economy. The thermal energy-based technologies employed in MSF, MEE, and HDH rely on traditional energy sources, specifically electricity. This technique can not apply for fisherman and salt producer. Therefore, a new method is essential to use renewable energy, low input cost and less efforts for the production of potable water especially for salt producer and fisherman.

However, the most straight forward, economical, and environmentally safe method of purifying water is solar distillation. One of the most straight forward methods for distilling brackish water using sun energy is solar distillation. Because solar distillation uses a non-traditional energy source as fuel, the solar distillation process is therefore a possible alternative to the standard distillation method. As a result, in areas with abundant sun radiation, solar distillation is the suitable method for purifying contaminated water. The apparatus used for the solar distillation is called as solar still. Solar stills have many advantages that include wide availability of solar energy, simple in construction and low-cost operation, near zero maintenance requirements, and low-cost construction. To overcome the scarcity of fresh water in Gulf of Kutch, the availability of long sea shore and abundant solar energy is the boon the application of solar distillation technology. Solar stills are suitable for small-capacity and self-reliant water supply systems as they can only produce potable water by solar energy. Solar distilled water has a better taste than commercially distilled water; the main reason is that in solar distillation, the water is not subjected to a boiling process. Hence, its PH value is unaffected.

Solar Still

Distillation of brackish water using solar energy is recognized as solar distillation. The apparatus used for solar distillation is known as a solar still. Solar distillation has been used to generate lower quantity safe / pure water where we need in remote area where supplies is not possible. Accordingly, distillation by solar still is promising since it can eliminate bacteria and other inorganic, organic, non-volatile pollutants from water [6]. TDS levels can be lowered by up to 30 PPM, which is safe for consumption and drinking.

Solar stills are primarily categorized as passive and active systems [7]. The most popular type of solar still is a basic passive still, in which the distillation and heat collection processes are carried out in the same apparatus. Low productivity is the biggest disadvantage of the passive still. Passive stills are simple in design and more effortless in fabrication at a low cost, therefore suitable for house-hold use. The active solar still uses an additional source to heat the saline water in the basin more quickly through evaporation, such as solar collectors, solar ponds, waste heat from industry, and power plants. However, it is concluded that passive solar stills are inexpensive sources of potable water, whereas the active ones are economical from a commercial point of view, such as in producing distilled water for retail purposes [1].

A. Basin Still

The most conveniently used solar distillation system consist of simple passive solar stills shown in Figure 5 and Figure 6, where the heat collection and distillation process take place within the same equipment.

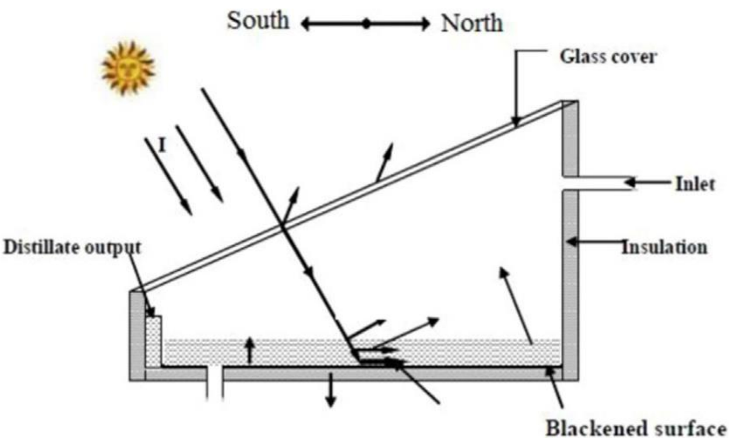

Figure 5. The Schematic View of a Single Effect Single Slope Basin Type Conventional Passive Solar Still.

It is less expensive to fabricate and has a simple, straightforward design. [8]. Solar radiation is as fuel / energy for solar still. The absorber plate absorbs the solar radiation and raises the basin water's temperature. As a result of the absorbed solar radiation, the water in the basin evaporates, producing water vapor that condenses when it comes into contact with the glazing cover. Following, drop of the distilled water begin to slide down along the glass cover due to gravity and are gathered and collected at the bottom of the inclined transparent cover (glazing cover). The best design basins for distillation are broad /wide structure to acquire larger surface area and shallow with an inner surface painted black, the black paint helps to capture as much solar energy as possible. To stop the evaporation of toxic volatiles or volatile chemicals with evaporation of saline water, surface of solar still would be painted with colour. Generally, in most cases, efficiency of single basin solar till was in the range of 30-45% and productivity less than 5 L/m^2/day under optimize condition [9]. It has lower efficiency mainly is due to the complete loss of latent heat of condensation of water vapor on the solar still glass cover and loss of heat at the side and bottom of surface of solar still.

Matt black paint is applied to the still basin to raise the water's temperature and quicken the evaporation process. The clear glass lid is used for condensation and collection. The distilled output rises as the temperature differential between the basin plate and the glass cover grows. The greenhouse effect is created by the glass cover, which confines the radiation within the still.

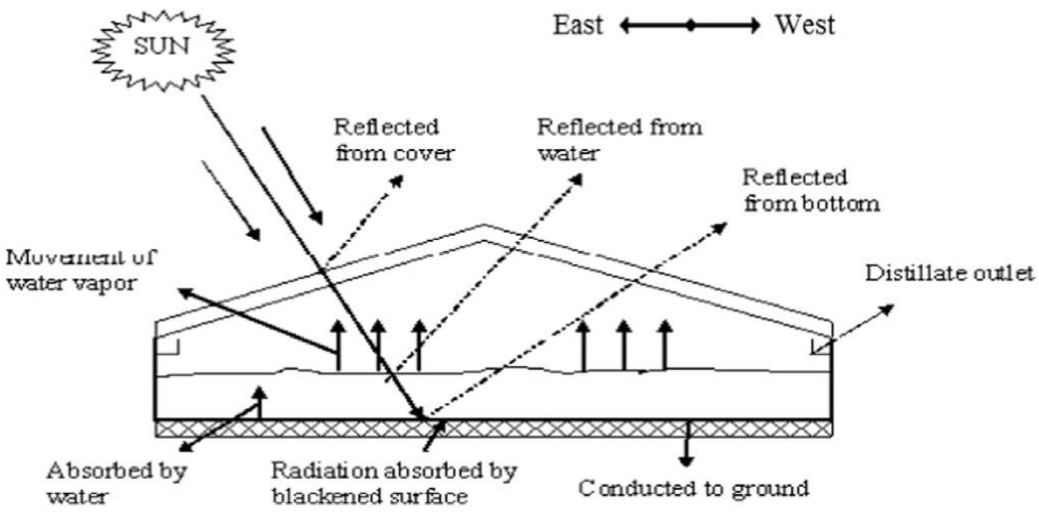

Figure 6. Single Effect Double (Dual) Slope Basin Type Conventional Passive Solar Still

B. Wick Still

Fig. 7 shows the architecture of a wick type solar still. The wick, which is a porous fabric or material, is stored at the bottom of the container. The light from the sun enters through the glass and is absorbed by the surface of the wick. The water passing through the wick rises to the surface due to capillary action, where the absorbed thermal energy heats it up. The heated water loses its latent heat of evaporation and condenses on the inside of the glass plate. Condensed droplets move on the sloping glass surface and gather in a container via the drainage that is supplied.

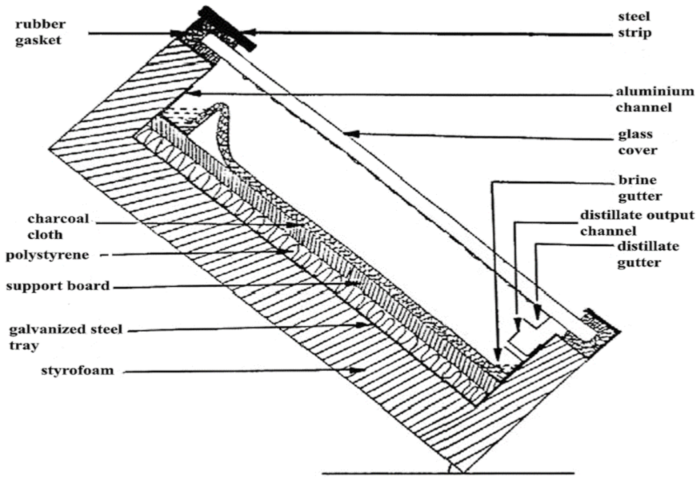

Figure 7. Wick Type of Basin Solar Still

Solar stills consist of the following components:

1. Glass cover, where the water vapor condensation takes place.
2. Saline water (brine) body.
3. Collector plate or basin-liner, where saline water is reserved to absorb the solar radiation.
4. Base with insulation to reduce heat loss.
5. Sidewalls or edges.
6. Water container feed.
7. Distillate output.
8. Vapor leakage.
9. Connecting pipes.
10. Atmosphere, where the solar thermal energy interaction takes place.

Multi-effect solar stills were used to improve production of desalinated water but only in small capacities, this is because the condenser is an integral part of the still.

Productivity of Solar still is affected by following parameter.

A. Environmental (climatic) parameters: solar radiation, ambient air temperature, wind speed, atmospheric humidity, sky conditions, vapour pressure etc.

B. Design parameters: thermos-physical properties of the material used in its construction, orientation of the still, spacing between the water surface and the transparent cover, number of glazing, vapour tightness, evaporation area, material of condensing cover, angle of condensing (glass) cover, cover thickness, types of insulation, insulation thickness, thermal storage materials and additives etc.

C. Operating parameters: water depth in the tray, absorptivity-transmissivity properties of the still, initial temperature of the water, water - glass cover temperature gap etc.

II. LITERATURE REVIEW

Comparing conventional stills to other distillation techniques, they are less energy-efficient and produce less distillate relative to their size and cost. For these reasons, they have not yet reached full commercialization. Many researchers tried to alter the design of solar still and design the components to increase the efficiency and productivity. Several research investigations are available in the literature on the control of design, and operating parameters to maximize the energy efficiency and productivity of the solar still [10]. Amendment in conventional solar still is provided in Figure 8.

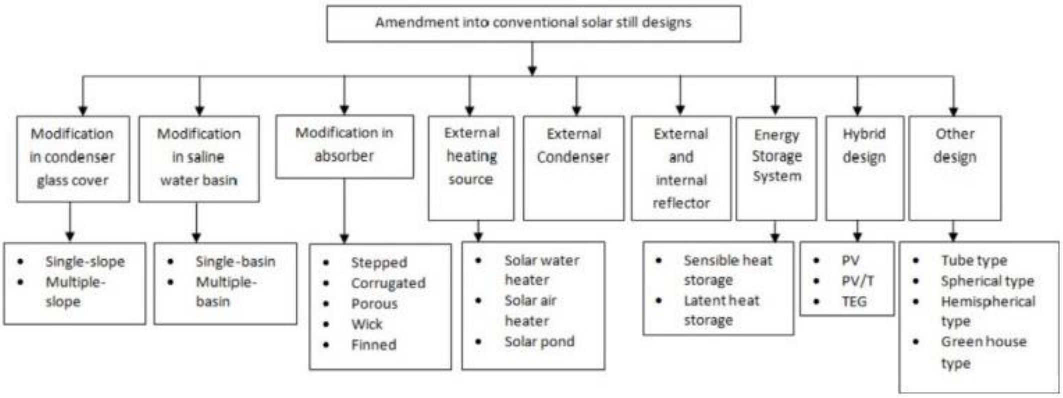

Figure 8. Amendment in Conventional Solar Still Design [10]

Passive solar thermal systems are that they are more economical and simple than active systems, as they require fewer components and no electricity. Because solar based still have fewer wear, tear points and sites of failure, they have a longer lifespan and require less maintenance. It is more suitable as it can blend in with the building's exterior or roof. It seems like aesthetically pleasing and less intrusive. Rural homes, isolated locations, or single-family homes may also benefit more from passive systems. Passive solar still require less space which is very essential to fisherman who has small size boat. Abundant availability of sea water plays crucial role in selection for solar still to obtain fresh a quality drinkable water. But climate condition plays important role to maintain the efficiency of conventional solar still. Hence literature review was to be done low cost passive solar still only. However, no review offers specific recommendations regarding effect of climate parameter on productivity of still. Solar still which is designed for fisherman and salt produce, have greater effect of moisture, wind velocity and ambient temperature on productivity. That's why this review project was undertaken. This review paper effect of climate parameter and location to decide the build a conventional passive solar stills.

Methodology

In this review paper, effect of climate parameters on solar still and enhance the productivity at lower cost are reviewed to investigate the most excellent solar still for fisherman and salt producer application. The pertinent research papers for this project have been gathered from a number of reputable international peer-reviewed journals. The selected papers are subsequently separated into five different groups, namely: Wind velocity, Ambient temperature, Vapour pressure, Solar radiation, Location. Each article, paper was studied to find out significant data and effect. Climate review was to be done to know the effect of climate which are not controlled. The outcome was made in every group to find the effect of climate parameter on conventional solar still. Finally, the effect of climate parameter has been studied to enhance the productivity and find out the most efficient value of climate parameter. Year-wise statistics of the number of papers reviewed in this article on solar stills is given in Figure 9.

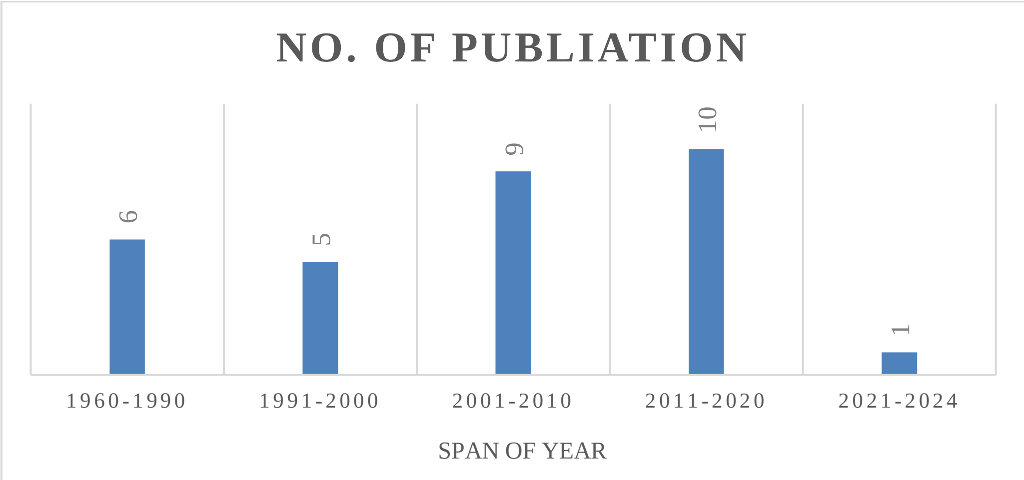

Figure 9. Span of Year-wise Statistics of the Number of Publication Reviewed on Solar Still

Investigation of Environmental(Climate) Parameter on Productivity of Solar Still

A. Wind velocity

The convective heat transfer coefficient from glass cover to environment (surrounding) increases as wind velocity increases. It increases the temperature difference between saline water and inner side glass cover. Eventually, it increases evaporation rate of saline water and performance of solar still increased. [11].

A double slope single basin was investigated by simulation thermal modelling to investigate the effect of ambient temperature and wind velocity [12]. It was found that productivity is increased with increase of ambient temperature and wind velocity [12].

A double slope single basin was tested by thermal modelling and practically to investigate the effect of ambient temperature and wind velocity [13]. It was found that at the lowest wind velocity there is a slight increase in output. The difference between 20 and 5 m.p.h, is only 3%, from which it may be concluded that the influence of wind on still output is unimportant. The performance of solar still improves with increment in solar radiation, ambient air temperature and wind speed [14]. It supports the result of [12].

An analytical model was developed to understand the effect of operating parameter [15]. The effect of wind velocity on productivity for the still is plotted in Fig. 10. Distilled output increased as wind speed increased and a 10% increase in output was seen when the wind speed increased from 1 m/s to 8.89 m/s.

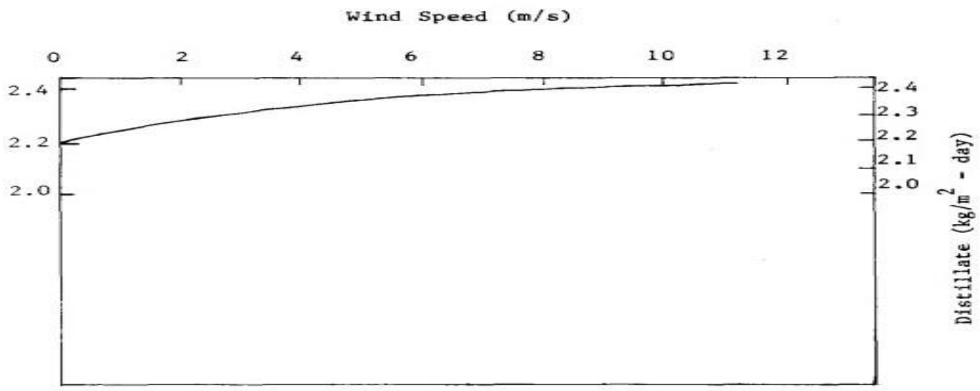

Figure 10. Analytical plot of the effect of wind speed on distillate output; 6 March 1978 [15].

A single basin solar still having a base area of 1.5 m^2 (1.5 × 1.0 m) was designed and fabricated from galvanized steel sheet with an inclined glass cover [16]. Reference [16] found that still productivity was increased with decrease in wind velocity. This is a contradict with their experiment results involving the effect of ambient temperature, since increasing wind velocity should have similar effect as that of decreasing ambient temperature. Both theoretical and experimental research was done on the solar distillation process in a single slope single basin [17]. The impacts of wind speed, water depth, and glass cover thickness are assessed on still production. The overall productivity is mostly unaffected by the wind speed. Increasing wind speed from 0 to 9 m/s increases the production by 10% (17).

Effect of wind was investigated on double slope single basin still without mirrors (DSSBS), double slope single basin still with outer mirrors (DSSBSMR), single slope double basin still (SSDBS), vertical still (VS) and single slope single basin still (SSSBS) by computer simulation [18]. Reference [18]) found that the daily productivity of solar stills increases as velocity increases until a typical velocity 10 and 8 m/s on typical summer and winter days, respectively. It is due to the increased temperature gap between water-glass more than the fall in both temperatures. Four identical units of a single sloped solar still were constructed and investigated for various parameters under the same operating conditions [19]. It is clear that with the increase in wind velocity, the productivity is decreased.

A report on the application of a mathematical model to forecast productivity of simple solar still in Oman under various design, operating, and environmental conditions was published [20]. Analysis of symmetrical double slope single basin was done. Figure 11 shows that effect of increasing the wind speed on the solar still is more significant than the effect of the ambient temperature. For instance, increasing the wind speed from 1 to 3 m/s results in an increase of 8% [20]. This may be explained by the fact that increasing the wind speed results in a higher heat transfer coefficient from glass cover to surrounding, which reduce the temperature of cover and increase condensation rate of vapour inside the still. Ultimately it enhances the distilled output.

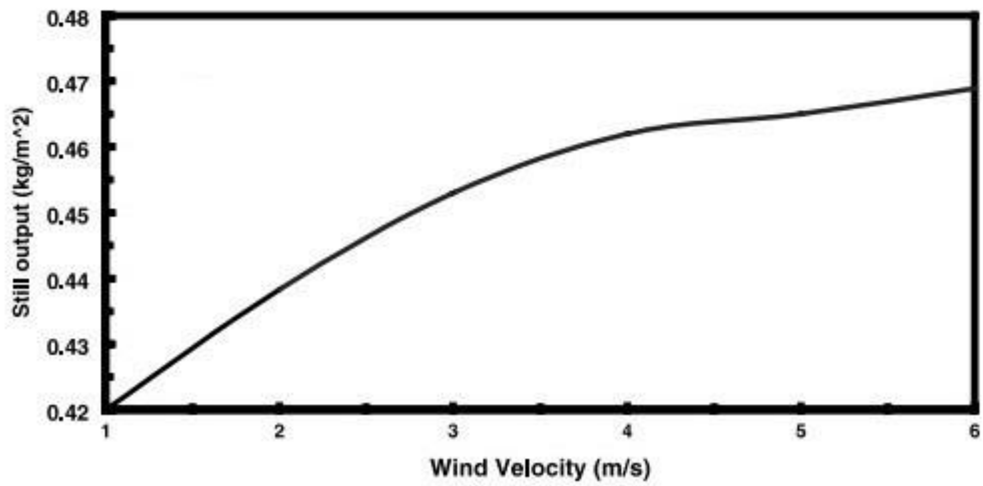

Figure 11. Effect of Wind Velocity on Single Basin Still Output [20].

The wind speed has a big impact on still productivity; if the wind speed increases from 0 to 10 m/s, the productivity can go up by more than 50% [21]. An experiment was done to understand an annual as well as seasonal performance of single slope passive solar still [22]. Effect of different water depths was analyzed in a single slope passive solar still of cover inclination of 30° [22]. The experiments were carried out on six clear days per month for 24 hours a day, at six different water depths, from June 2004 to May 2005. Experimental was performed at the IIT Delhi, India whose latitude is 28° 35′ N. It was found that increase in air velocity from 0.0 m/s to 2.4 m/s can increase the daily productivity 40.06% and 50.94% for water depths 0.02 m and 0.12 m respectively [22].

The performance of a single slope single basin solar still using different climate and operational parameters was studied experimentally at slope cover angle 32° [23]. The effects of ambient temperature and the wind velocity were studied. It was found that as the ambient temperature and the wind velocity increases, the productivity will increase [23]. The parametric analysis has also been carried out to determine the effects of several parameters, such as the water depth, wind velocity, collector absorbing surface, thickness of condensing cover of FPC based active solar still [24]. This analysis was to be performed at New Delhi (latitude: 28° 35′ N; longitude: 77 ° 12′ E) [24]. Experiment set up was provided in Figure 12.

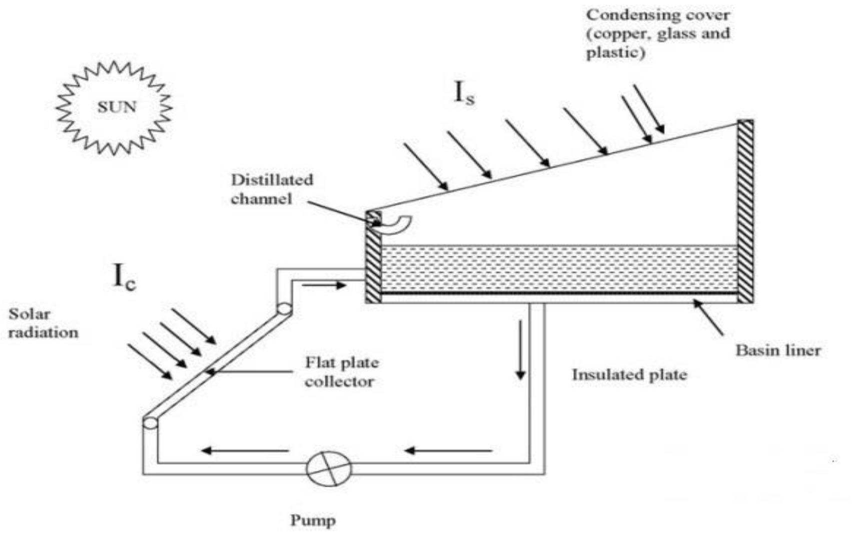

Figure 12. Cross Sectional View of an Active Solar Still Coupled with a Flat Plate Collector [24].

Figure 13 clearly indicates that as the wind velocity increases, the convective heat transfer coefficient from glass cover to ambient air increases and simultaneously the glass cover temperature decreases. It increases difference of water-glass cover temperature and ultimately increased overall yield [24].

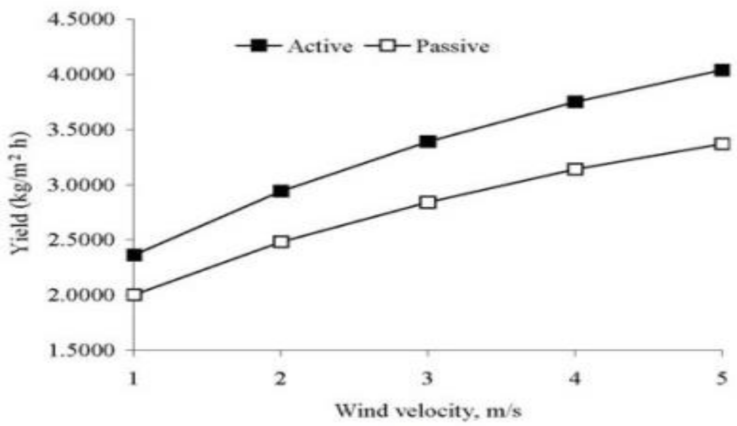

Figure 13. Variation of Yield on Effects of Wind Velocity [24].

An attempt is made to enhance of the double slope single basin passive solar still productivity using an external fan [25]. External cooling fan was used for cooling the glass surface of the solar still decreased the productivity by 4% and 8% for wind speed 7 and 9 m/s respectively. Reddy, & Reddy (2009, as cited [11]) investigate effect of wind speed on double slope single basin using thermal analysis and correlation model on various heat and mass transfer coefficients and found good agreement and it is as shown in Figure 14.

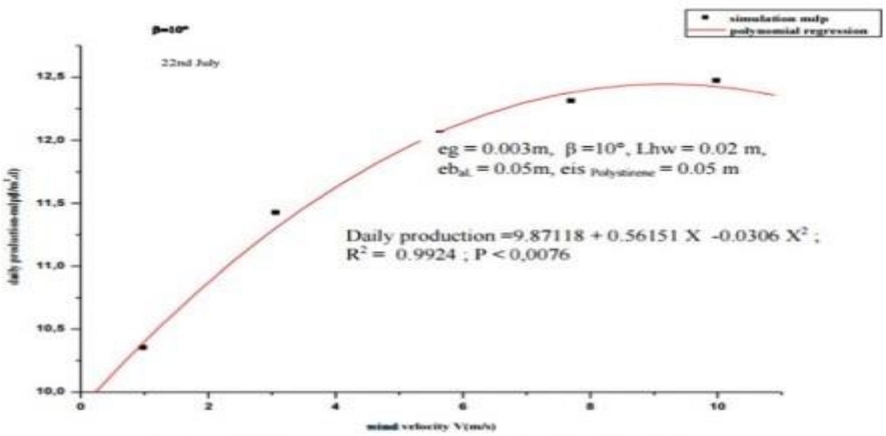

Figure 14. Correlation Model of Effect of Wind on Passive Solar Still [11].

It was found that distillation output when wind speed at 1.14 m/s, 2.06 m/s, 2.92 m/s and 4.01 m/s is 44.7%, 53.8%, 56.3% and 50.2% respectively (Reddy, & Reddy, 2009, as cited in [11]).

The effect of wind velocity (climate parameter) on solar still was summarized in Table 2.

Table 2. Assessment of Increment in Wind Speed on Passive Solar Still

Sr. No.	Author (s)	Types of Solar Still	Computational Method	Effect on Productivity	% changed
1	Cooper [12]	Double slope single basin passive solar still	Simulation	Increased	
2	Morse and Read [13]	Double slope single basin passive solar still	Modelling and Experimental	Slight reduced or unaffected	
3	Garg and Mann [14]	Single slope single basin still	Experimental	Increased	
4	Rajvanshi [15]	Single slope single basin passive solar still	Modelling	Increased	10%
5	Farid and Hamad [16]	Single slope single basin passive solar still	Experimental	Decreased	
6	Toure and Meukam [17]	Single slope single basin passive solar still	Modelling and Experimental	Increased	
7	El-Sebaii [18]	DSSBS, DSSBSMR, SSDBS, VS and SSSBS	Computer Simulation	Increased upto 10 m/s	
8	Nafeya et al. [19]	Single slope single basin passive solar still	Experimental	Decreased	
9	Al-Hinai et al. [20]	Double slope single basins still	Modelling	Increased upto 10 m/s	8%
10	Zurigat and Abu-Arabi [21]	Single slope single basin still with 2 glass cover	Modelling and Experimental	Increased upto 10 m/s	50%
11	Tiwari and Tiwari [22]	Single slope single basin still	Experimental	Increased at 2.4 m/s	50.96%
12	Badran [23]	Single slope single basin still	Experimental	Increased	
13	Dimri et al. [24]	Active solar single slope solar still coupled with a flat plate collector	Modelling and Experimental	Increased	
14	Al-Garni [25]	Double slope single basin passive solar still with external fan	Modelling and Experimental	Decreased	4 and 8% for wind speeds 7 and 9 m/s respectively
15	Reddy, & Reddy (2009, as cited in Panchal, 2017)	Double slope single basin passive solar still	Modelling	Increased	

B. *Ambient Temperature*

Many researchers from all around the world have investigated the effect of variation in ambient temperatures on solar still distillate output by using a theoretical model [26].
By using simulation thermal modeling, the effects of wind velocity and ambient temperature were examined in a single basin with a double slope [12]. It was discovered that when the outside temperature and wind speed rise, productivity rises [12].
Effect of various parameters, such as wind velocity, ambient temperature and heat loss from the base were observed in double slope passive solar still [13]. It was seen that an ambient temperature change from 80ºF to 100°F causes an 11% increase in output, and a change from 80ºF to 60°F causes a 14% drop [13]. Rise in an ambient temperature, increases the productivity and vice versa.
By employing dyes to raise the water's absorptivity, raising the water's initial temperature (utilizing warmed water) and decreasing water depth rises a still production [14]. To comprehend the impact of the operational parameter, computer based simulation on an analytical model was performed [15]. A 40% rise in ambient temperature rise 27% productivity of solar still [15]. Result of analytical model concur with result that have been published by [12], [13], and [14].
A 1.5 m^2 (1.5 m × 1.0 m) base area single-basin solar still with an angled glass cover was developed and constructed using galvanized steel sheet [16]. The rise in ambient temperature was associated with an increase in still productivity [16] and [19]. Investigation was done using a mathematical model to forecast the distilled output of a conventional solar still under various design, operational, and meteorological conditions in Oman [20]. A single basin with symmetrical double slope was analyzed. It was found that increasing the ambient temperature tend to increase the yield of the solar still. Figure 15 shows that increasing the ambient air temperature from 23 ºC to 33 ºC increases the still yield by 8.2% [20].

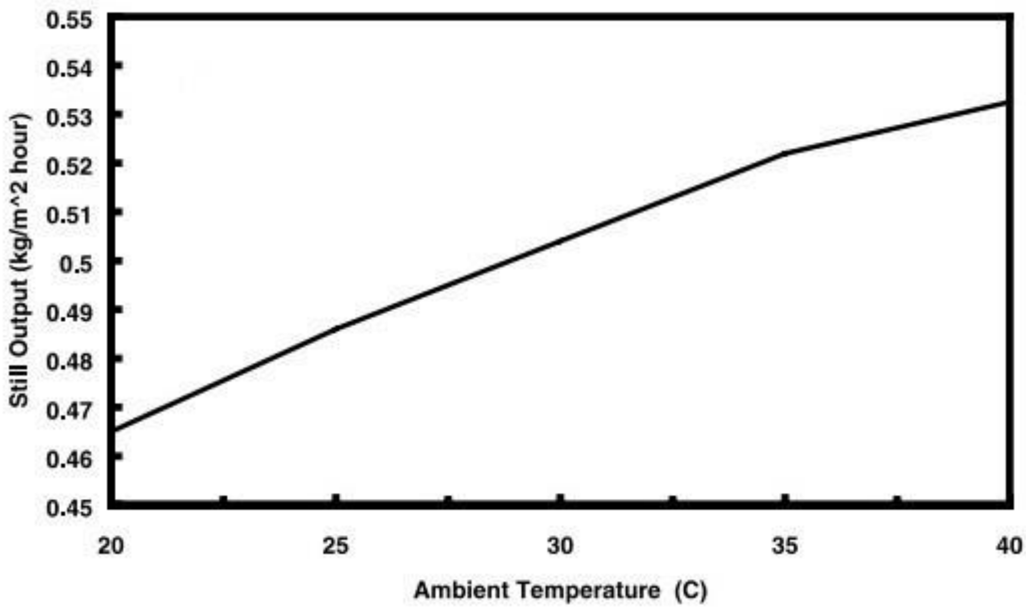

Figure 15. Effect of Ambient Temperature on Passive Solar Still [20].

The performance of a single slope single basin solar still using different climate and operational parameters was studied experimentally at slope cover angle 32º [23]. The effects of ambient temperature and the wind velocity were studied. It was found that as the ambient temperature and the wind velocity increases, the productivity will increase.
A new type portable thermoelectric solar still (PTSS) was incorporated with thermoelectric module and heat pipe [27]. Experiment was performed under the climatic condition of Semnan (35° 33′ N, 53° 23′ E) for 5 days. It was found that daily productivity increased as ambient temperature increased [27].
The amount of distillate produced by a solar still is dependent upon local climate factors such as sun radiation and ambient temperature. Variation of solar radiation and ambient temperature was investigated [28]. The experimental set up of solar still with vacuum tube was installed at Mehsana (latitude of 23º 59′ and longitude of 72º 38′) Gujarat, India. Data was taken on 05/04/2012 and graph was plotted as shown in Figure 16. Panchal [28] concluded that there is direct relationship between the solar radiation and ambient temperature.

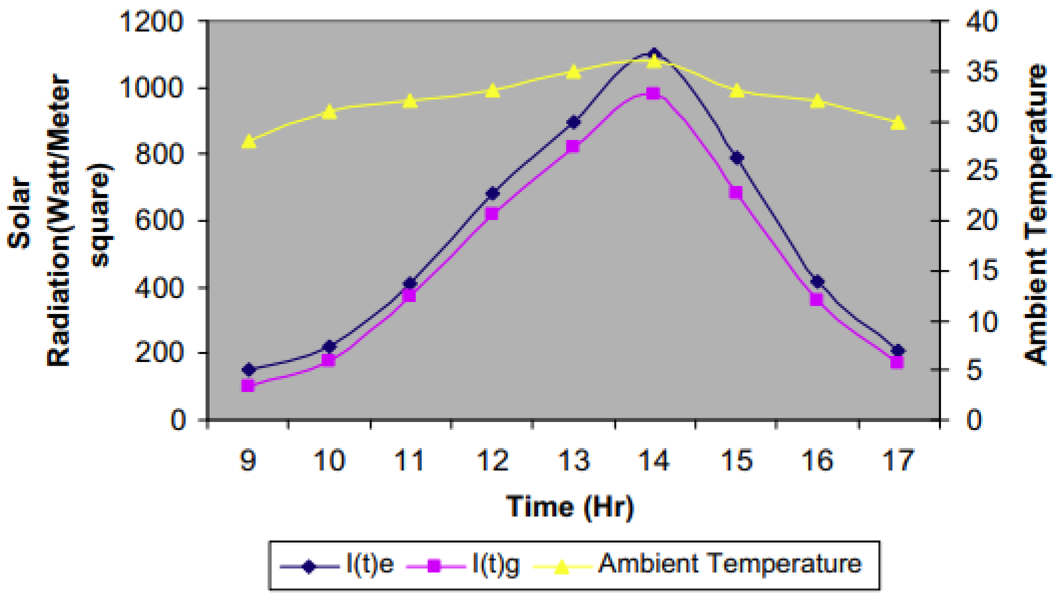

Figure 16. Variation of ambient temperature and solar radiation [28].

The effect of ambient temperature on solar still is summarized Table 3.

Table 3: Effect of Ambient Temperature on Passive Solar Still

Sr. No.	Author (s)	Types of Solar Still	Computational Method	Effect on Productivity
1	Cooper [12]	Double slope single basin passive solar still	Simulation	Increased
2	Morse and Read [13]	Double slope single basin still	Theoretical and Experimental	Increased
3	Garg and Mann [14]	Single slope single basin still	Experimental	Increased
4	Rajvanshi [15]	Single slope single basin passive solar still	Simulation	Increased
5	Farid and Hamad [16]	Single slope single basin still	Theoretical and Experimental	Increased
6	Nafeya et al. [19]	Single slope single basin passive solar still	Experimental	Increased
7	Al-Hinai et al. [20]	Double slope single basin still	Modelling	Increased
8	Badran [23]	Single slope single basin still	Experimental	Increased
9	Rahbar and Esfahani [27]	Single slope single basin still with thermoelectric module and heat pipe	Experimental	Increased

C. Solar Radiation

Solar radiation intensity is the most vigorous role in the productivity of solar still. Many former researchers have investigated the effect of solar radiation on solar still distillate output theoretically and experimentally. An investigation was done about the relationship between solar radiation and ambient temperature [28]. It was concluded that there is direct relationship between the solar radiation and ambient temperature [28]. It was also agreed former publication [23]. According to Malik, Tiwari, Kumar, and Sodha [26], about 11% of the

radiation that the still basin receives gets reflected back without being used. This loss can be minimized, if the absorption coefficient of the still basin and water is increased.
A double slope single basin was tested by thermal modelling and practically to investigate the effect of ambient temperature and wind velocity [13]. It was found that daily distillate output is increased as increase in daily insolation as shown in Figure 17.

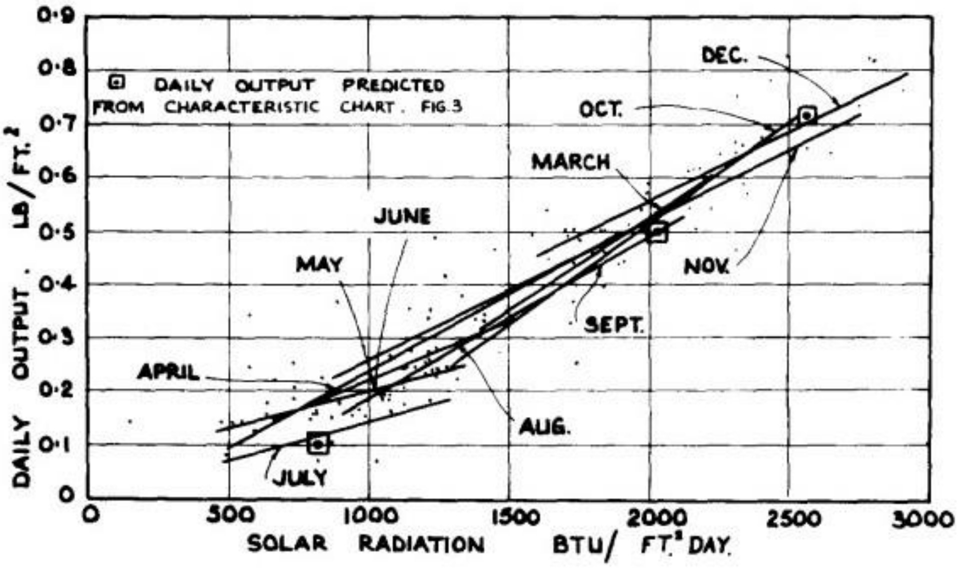

Figure 17. Effect of Daily Isolation on Solar Still Distilled Output [13].

Okeke, Egarievwe and Animalu [29] exhibited that, distillate output is directly proportional to the solar radiation. A single-basin solar still having a base area of 1.5 m^2 (1.5 m x 1.0 m) was designed and fabricated from galvanized steel sheet with an inclined glass cover [16]. Efficiency of the still was found to be independent of solar radiation, however, an increased diffused radiation lead to slight decrease in its efficiency [16].
A new type portable thermoelectric solar still (PTSS) was incorporated with thermoelectric module and heat pipe [27]. Experiment was performed under the climatic condition of Semnan (35° 33′ N, 53° 23′ E) for 5 days. It was has found that daily productivity follows the intensity of solar radiation as shown in Figure 18 [27].

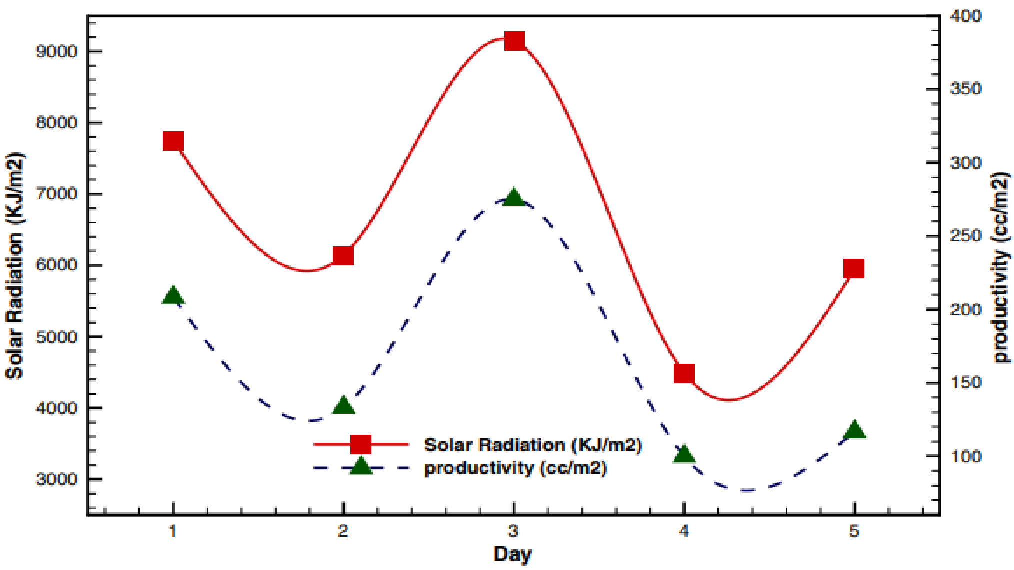

Figure 18. Variation of Daily Productivity and Total Solar Radiation During 5 Days of Experiments [27].

D. Vapour Pressure

Variation in vapour pressure of surrounding air does not effect on the productivity of passive solar still [14].

E. Location

A technical comment on the effects of weather, operational factors, and design specifications on the year-round performance of single slope and dual slope solar stills in the context of an Indian dry region was presented [14]. Effect of location on yearly total solar radiation have been investigated. Data were provided in Table 4 and Table 5

Table 4

Seasonal Variation of Total Solar Radiation (cal/cm^2 day) Incident on Glass Cover of Double Slope Solar Still Facing East-West and North- South [14]

Place	Direction Of Long Axis	Winter (Dec - Feb)	Hot Weather (Mar – May)	Monsoon (June – Sep)	Post Monsoon (Oct – Nov)
Jodhpur (26.3^o N)	East – West	334	514	448	376
Jodhpur (26.3^o N)	South - North	340	489	414	377
Madras (13.06^o N)	East – West	357	458	397	318
Madras (13.06^o N)	South - North	354	460	399	320

It is seen from this Table 4 that for Madras, a low latitude station, almost equal radiations are received irrespective of orientation. However, at Jodhpur, a high latitude station, east-west orientated solar still receives significantly more radiation than the south-north oriented solar still in the hot weather and monsoon period.

Table 5

Yearly Total Solar Radiation (cal/cm^2 day) Received for Both the Orientations for Double Slope Solar Still and Single Slope Solar Still Facing South [14]

Place	Double slope single basin passive solar still		Single slope single basin still facing south
	East-West Orientation	South-North Orientation	
Jodhpur (26.3^o N)	427	408	480
Madras (13.06^o N)	389	390	410

As per Table 5, it can also be seen that for Jodhpur the east-west orientation receives more radiation than the south-north orientation, taking the year as a whole, while there is no effect of orientation in case of Madras for double slope single basin solar still. In lower and higher latitude places, the single slope solar still receives more solar radiation than the dual slope solar still.

A multiple regression equation relating the productivity of the still with environmental parameters such as solar insolation, ambient air temperature and wind speed has been developed and the correlation coefficient is 0.8991 [14]. Both the channels of dual slope solar still collect equal quantity of condensed water [14].

For places with higher latitude than 20°, only single slope stills are preferable since in double slope still, one side will remain shaded for most of the time [30]. For places with latitude higher than 20°, single slope still is preferable and for lower latitude places double slope stills are preferred with south–north orientation [30]. Murugavela et al. [30] suggested to increase the area for condensation, to avoid production loss by falling back of water drops back into basin from glass lower surface. It is better that solar rays near normal to solar still with integrated condenser. It is suggested that single slope solar still with south facing cover is used for north latitude places and with north facing cover is used for south latitude places.

F. Humidity

Single slope single basin was analyzed by numerical method (Abu-Hijleh , Bassam A. K., & Mousa, H. A. (1997). It was concluded that humidity increase 0 to 100% reduce slight percentage change from 12.8 to 12.0%. It is shown in Figure 19 [14].

III. CONCLUSION

This review exhibits the factors affecting on the distillate output of solar still. In this review, most important factors include climate parameters are considered. The distilled output of passive solar still are dependent upon the environmental parameter like wind velocity, ambient temperature, solar radiation, and location. Key points summarize about different climate parameter cited in this article were given below.

- At low latitude station in India, yearly total radiation and seasonally radiation are approximately equal irrespective of E-W or N-S orientation for double slop single basin solar still. At high latitude, the east-west orientation receives more radiation than the south-north orientation, taking the year as a whole, while there is no effect of orientation in case of lower latitude for long axis of the conventional double slope single basin solar still.
- The single slope solar still single basin facing south collects greater amount of solar radiation as compared to the dual slope single basin solar still at lower and higher latitude locations. Single slope solar still with south facing cover is used for north latitude places and with north facing cover is used for south latitude places.
- Productivity of still increase with increasing wind speed but performance of still little bit decrease with higher wind velocity approximately more than 9 m/s.
- There is direct relationship between the solar radiation and ambient temperature. The daily distilled output (productivity) increases as ambient temperature increases.
- The productivity remains intact during the variation in vapour pressure of surrounding air on passive solar still.
- Daily productivity of still is directly promotional to the solar radiation.
- There is no significant effect on productivity of solar still with change in humidity.

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