# Experimental Investigation on The Performance of Air Humidifying System with Desiccant Regenerator Using Solar Water Heater

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## Abstract

Solar based air conditioning systems are becoming more and more popular in warmer and humid regions keeping in mind the environmental issues. The implementation of liquid desiccant in air conditioning system reduces the application of environment unfriendly refrigerants. Experimental investigation on the performance of air humidifying system with desiccant regenerator using solar water heater has been exhibited in this analysis. Hot water from the tank having in the solar powered heating system has been flowed to a heat exchanger through piping system and returned back to the storage tank. Atmospheric air has been passed through the heat exchanger. The heated air from the heat exchanger has been blown into a $CaCl_2$ solution for the purpose of regeneration of $CaCl_2$ which has been considered as the working desiccant in this analysis. In this experiment different concentrations of $CaCl_2$ solution such that 32.67gm/kg-water, 39gm/kg-water, 66.67gm/kg-water, 150gm/kg-water and 231.12 gm/kg-water have been used to evaluate the performance. Air flow rate, specific humidity, cooling rate of the desiccant cooling system, evaporation rate have been calculated. The effect of different concentrations of the $CaCl_2$ solution at the air velocity of 2m/s and 3m/s on evaporation rate and cooling rate have been analyzed. Evaporation rate and cooling rate decrease with the increase of concentration of the solution. The evaporation rate and cooling rate increase about 25% - 49.5% with the increase of the air velocity from 2m/s to 3m/s.

## Keywords
Liquid desiccant, Regeneration, Evaporation rate, Cooling rate, Solar energy

## 1. Introduction
The necessity of using cooling systems by the implementation of solar power for air-conditioning and refrigeration motive in heated and humid regions has been increasing day by day. Due to the rising of consciousness to environmental problems, the air conditioning system using solar power is being the center of interest in recent years. Conventional technologies of cooling that use refrigerant need huge energy. The conventional technologies keep negative impact on the environment. The use of liquid desiccant based air conditioning is being popular day by day.
Regeneration is an important component in the liquid desiccant based air conditioning system. For the purpose of controlling humidity liquid desiccant absorbs water vapor from the atmospheric air. It is also necessary to remove the water from the desiccant to reuse in the system. So heated dry air is passed to the liquid desiccant to regenerate and humid air exit from the desiccant regenerator. For examining the regeneration process various designs of regenerator have been analyzed and different theoretical models have been applied.

### 1.1 Objectives
A few targets are detailed to introduce the general objective of the current analysis; utilization of solar based water heater combined with desiccant regenerator for regeneration of $CaCl_2$ solution. The objectives are given below:

1. Establishment of a solar water heating framework combined with an air heater and air humidifier to regenerate the $CaCl_2$ system.
2. Study and examine the task of the proposed framework and evaluate the performance for different concentrations of the solution at air velocity of 2 m/s and 3 m/s.
3. Evaluate the impact of the inlet parameters of air flow (for the most part air temperature) on the regeneration procedure.

## 2. Literature Review

Yang and Wang (1994) performed an experimental study of a forced convection solar collector/regenerator for open cycle absorption cooling and showed that, when the concentration of inlet solution was low the counter-flow case could improve the collector/generator efficiency. Grossman (2002) demonstrated an experimental investigation on solar powered system for cooling dehumidification and air conditioning. The implementation of solar power in air conditioning system is being the main concern in todays world (Grossman 2002). Aly et al. (2011) demonstrated a theoretical investigation on the performance of LiCl absorption cooling system by applying an artificial neural network (ANN) model. The result showed that the model could be successfully implemented to predict the overall performance of the system and investigate the effect operating parameters under different atmospheric conditions. Kakabayev and Khandurdyev (1969) developed an analytical process in terms of the properties of solution and conditions of climate to calculate the evaporated mass from the weak solution in the regeneration process. Utilizing a radiation processor that uses the statistical meteorological data for summer season at Kaohsiung, Taiwan, Yang and Wang (2001) accomplished a computer based simulation for the collector/regenerator systems. To stimulate the performance of solar powered open absorption system for cooling, numerous studies on theoretical modeling have been done (Yang and Yan 1992). To analyze the performance of a forced parallel flow solar regenerator, Alizadeh and Saman (2002) displayed a computer model where $CaCl_2$ was used as the working desiccant. An examination of the framework was introduced to ascertain the evaporation rate of liquid (water) from the desiccant solution as a function of the factors of the system and the atmospheric conditions using aqueous solution of lithium bromide in M-cycle indirect evaporative cooling system. Gae et al. (2014) showed that, dehumidification process increased with the increase of humidity ratio and inlet air flow rate but decreased cooling capacity of the evaporative cooler. Cooling capacity and moister removal rate of the evaporative cooler enhanced with the increase of inlet concentration and flow rate of LiBr aqueous solition. Using solar water heater to regenerate the $CaCl_2$ aqueous solution Alosaimy and Hamed (2011) performed a theoretical and experimental investigation. The result of this analysis showed that to regenerate $CaCl_2$ solution from 30% to 50% solar water heater could be utilized. Using solid and liquid desiccant Kim et al. (2015) demonstrated that the upstream side (at primary air side) desiccant system consumed 76-85% less power comparing to downstream side.

Cui et al. (2019) developed a computational model for the measurement of performance of heat and mass transfer to analyze the function of liquid desiccant indirect evaporative cooling system. This model demonstrated better similarity with experimental data. The film length of liquid desiccant, intake air temperature and humidity ratio created an impact on outside humidity ratio and temperature which shown by the simulation results. Using $CaCl_2$ solution as a working desiccant Bansal et al. (2011) showed experimentally that the effectiveness of internally cooled packed-bed dehumidifier was greater than adiabatic. The experiment was done using adiabatic and internally cooled packed-bed dehumidifier. Using $CaCl_2$ solution as a working desiccant Kabeel and Bassuoni (2013) performed a theoretical investigation on a liquid desiccant regenerator that was supported with scavenging air heat exchanger. The result of the analysis showed that the capability of desorption was enhanced causing air to become more wet as scavenging air temperature enhanced. In this analysis solar energy has been introduced for the regeneration of $CaCl_2$ solution which is considered as liquid desiccant. $CaCl_2$ desiccant shows higher absorption rate than other solutions. It is cheap, available environment friendly. The framework has been included a solar panel which is utilized for increasing water temperature in the water tank. The heated water is then used to warm the air which has been blown towards a radiator type heat exchanger. Then the heated air is passed through the liquid desiccant solution to regenerate the solution. The hot dry air to the regenerator extract water vapor from the desiccant solution.

## 3. Methods

In this experiment, $CaCl_2$ solution has been regenerated in a desiccant regenerator. The regeneration process has been done by flowing heated air. The atmospheric air is heated by using a radiator type heat exchanger. Hot water has been circulated within the heat exchanger to heat the streaming air. In this experiment water has been circulated from storage tank which operate in the solar power. Figure 1 shows a designed diagram of experimental setup. The solar panel has been installed on the roof of ME department, CUET, Chattogram. A water tank is connected to the solar panel via glow plug. High temperature water has been siphoned by a water circulating pump within the radiator type heat exchanger and then returned back to the tank.

Atmospheric air that has been drawn into the radiator will be utilized to regenerate the $CaCl_2$ solution. The solution has been circulated in the desiccant regenerator. The heat exchanger, which is used to heat air, has been introduced at the entrance zone of the humidifier. Solution from the solution pan in the humidifier has been siphoned to the highest point of the regenerator and flows downward, while heated air has been blown through the liquid desiccant.

Pipes have been utilized to make connection between the indoor units (air heater and regenerator) as well as the outdoor unit (solar heating system).

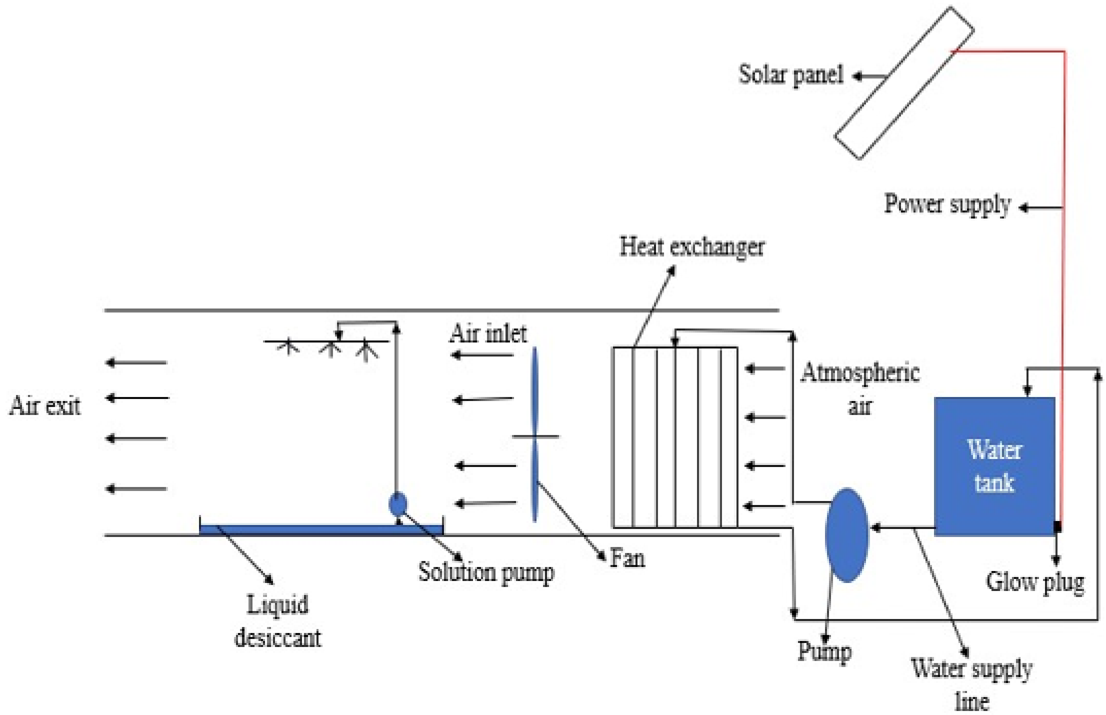



Figure.1: Designed diagram of experimental setup

In this experiment different concentrations of $CaCl_2$ solution such that 32.67 gm/kg-water, 39 gm/kg- water, 66.67 gm/kg-water, 150 gm/kg-water and 231.12 gm/kg-water have been used to evaluate the performance. The speed of air has also been controlled here. The mass of $CaCl_2$ and the concentration of the solutions have been measured at first. The experiment has been done for each concentration of solution individually for air velocity of both 2 m/s and 3 m/s. Before the investigation, hot water from the storage tank has been circulated to the heat exchanger and then fan, solution pump, water pump has been started. The hot water inlet and exit temperatures, air inlet and exit temperature to the desiccant regenerator have been measured during the analysis. Additionally, the relative humidity of air at entrance and outlet of the humidifier has been examined in the time of the experiment.

## 4. Data Collection

The outer radius of the fan, $r_o = 14.2\ cm$
The inner radius of the fan, $r_i = 3.2\ cm$

The projected area, $A = \pi(r_o^2 - r_i^2)$
$= \pi(0.142^2 - 0.032^2)$

$\therefore A = 0.0601 m^2$
Latent heat of evaporation, $L = 2260000\ J/kg$

Water inlet and exit temperatures to the tank have been measured by thermometers. Air inlet and exit temperatures and relative humidity have been measured by digital hygrometer. The speed of the air has been measured by anemometer. Data has been collected at different time for five calcium chloride solutions of 32.67 gm/kg water, 39 gm/kg water, 66.67 gm/kg water, 150 gm/kg water and 231.12 gm/kg water at 2 m/s and 3 m/s air velocity.
Water inlet and exit temperatures, air inlet and exit temperatures, Day time, relative humidity for inlet and exit conditions for different concentration of the solution are given below in table 1 and 2 for 2 m/s and 3 m/s air velocity respectively.

Table 1. Different data for 2 m/s air velocity at variable concentrated solutions corresponding day time.

| Concentration of the $CaCl_2$ solution (gm/kg water) | Water inlet temp ($^0C$) | Water exit temp ($^0C$) | Air inlet temp ($^0C$) | Air exit temp ($^0C$) | Relative humidity at inlet (%) | Relative humidity at exit (%) | Day time (hr) |
|---|---|---|---|---|---|---|---|
| 32.67 | 38 | 34 | 31.5 | 31 | 87 | 93 | 11.00 |
| | 38 | 35 | 31.6 | 31.2 | 86 | 91 | 11.30 |
| | 40.5 | 37.5 | 32.3 | 32 | 82 | 86 | 12.00 |
| | 42 | 38 | 33.1 | 32.8 | 78 | 82 | 12.30 |
| 39 | 36.5 | 34.5 | 32 | 31.6 | 81 | 86 | 11.00 |
| | 38 | 35.5 | 33 | 32.4 | 80 | 86 | 11.30 |
| | 40 | 37 | 33.7 | 32.7 | 76 | 84 | 12.00 |
| | 41 | 37.5 | 33.8 | 33 | 75 | 82 | 12.30 |
| 66.67 | 37.2 | 33.5 | 31.5 | 30.7 | 74 | 81 | 11.00 |
| | 38.5 | 34.1 | 32.1 | 31.4 | 70 | 76 | 11.30 |
| | 40 | 35 | 32.5 | 31.9 | 68 | 73 | 12.00 |
| | 40 | 36 | 32.4 | 31.8 | 68 | 73 | 12.30 |
| 150 | 37 | 34.2 | 31.2 | 30.7 | 80 | 85 | 11.00 |
| | 38 | 34 | 31.7 | 31.6 | 79 | 81 | 11.30 |
| | 40 | 36 | 32.6 | 32.1 | 75 | 79 | 12.00 |
| | 41 | 36.5 | 33.1 | 32.5 | 70 | 74 | 12.30 |
| 231.12 | 37 | 35.5 | 31.9 | 31.4 | 82 | 86 | 11.00 |
| | 38 | 36.8 | 32.2 | 32.0 | 84 | 86 | 11.30 |
| | 40 | 38.2 | 33 | 32.5 | 80 | 84 | 12.00 |
| | 41 | 39 | 33.5 | 33.1 | 77 | 80 | 12.30 |

Table 2. Different data for 3 m/s air velocity at variable concentrated solutions corresponding day time.

| Concentration of the $CaCl_2$ solution (gm/kg water) | Water inlet temp ($^0C$) | Water exit temp ($^0C$) | Air inlet temp ($^0C$) | Air exit temp ($^0C$) | Relative humidity at inlet (%) | Relative humidity at exit (%) | Day time (hr) |
|---|---|---|---|---|---|---|---|
| 32.67 | 40.5 | 36.8 | 33.6 | 32.6 | 71 | 79 | 13.00 |
| | 40 | 36 | 33 | 32.5 | 73 | 78 | 13.30 |
| | 41 | 37 | 33.3 | 32.8 | 71 | 76 | 14.00 |
| | 40.5 | 36.9 | 33.7 | 32.7 | 70 | 78 | 14.30 |
| 39 | 42 | 38 | 34.5 | 33.9 | 70 | 75 | 13.00 |
| | 42 | 36.8 | 34.5 | 33.9 | 70 | 75 | 13.30 |
| | 40 | 36 | 33.2 | 32.5 | 74 | 80 | 14.00 |
| | 39 | 35.2 | 32.4 | 31.3 | 74 | 83 | 14.30 |
| 66.67 | 41 | 36.3 | 33.5 | 32.9 | 64 | 69 | 13.00 |
| | 41.5 | 36.5 | 33.7 | 32.5 | 63 | 71 | 13.30 |
| | 40 | 36 | 32.1 | 31.4 | 70 | 76 | 14.00 |
| | 39 | 34.8 | 31.5 | 30.5 | 71 | 79 | 14.30 |
| | 41 | 37 | 33.3 | 32.5 | 68 | 73 | 13.00 |
| | 40 | 36.5 | 33 | 32.4 | 69 | 73 | 13.30 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 150 | 40 | 36 | 32.4 | 32 | 72 | 75 | 14.00 |
| | 41 | 37 | 31.8 | 31.2 | 74 | 79 | 14.30 |
| 231.12 | 42 | 39.5 | 34.2 | 33.8 | 77 | 80 | 13.00 |
| | 42 | 40 | 34.9 | 34.3 | 74 | 78 | 13.30 |
| | 41 | 39 | 33.5 | 33 | 77 | 81 | 14.00 |
| | 41 | 38.9 | 33.6 | 33 | 75 | 79 | 14.30 |

## 5. Results and Discussion

Data has been collected from experiment at different conditions of the atmosphere and calculated by the stated equations given below. Due to the variation of atmospheric temperature, the temperature of the water in the storage tank also varies. So the temperature of the air into the heat exchanger and the relative humidity also fluctuates with day time.
Air flow rate has been calculated using equation (1),

$$Q = Av \qquad (1)$$

Where $v$ is the velocity of air
Mass of air supplied has been calculated using the equation (2),

$$m_a = \frac{Q}{V} \qquad (2)$$

Here $V$ is specific volume for inlet condition of air to the desiccant regenerator which is calculated from psychometric chart.
Amount of water vapor added to the air or rate of water evaporation and cooling rate of desiccant cooling system have been obtained using equations (3) and (4) respectively,

$$m = m_a(W_2 - W_1) \qquad (3)$$

Here $W_1$ and $W_2$ are the specific humidity for inlet and outlet condition of the desiccant regenerator which are calculated from the psychometric chart.

$$H = mL \qquad (4)$$

Here L is latent heat of water vaporization.

### 5.1 Numerical Results

Using psychometric chart with the data of air inlet and exit temperatures and relative humidity specific humidity have been calculated for the different times. To find the mass of air supply, rate of water evaporation, cooling rate of the desiccant cooling system the equations (2), (3), and (4) are applied respectively

Table 3. Data evaluation for 2 m/s air velocity and different solutions

| Con. of the $CaCl_2$ solution (gm/kg water) | Specific humidity at inlet W1 (kg/kg of dry air) | Specific volume at inlet V ($m^3$/kg of dry air) | Specific humidity at exit W2 (kg/kg of dry air) | ($W_2$-$W_1$) | Mass of air supply $m_a$ (kg/s) | Rate of water evaporation m (gm/min) | Cooling rate of desiccant cooling system H (W) |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 32.67 | 0.0257 | 0.899 | 0.0268 | 0.0011 | 0.133704 | 8.82 | 332.37 |
| | 0.0256 | 0.899 | 0.0265 | 0.0009 | 0.133704 | 7.22 | 272 |
| | 0.0253 | 0.901 | 0.0262 | 0.0009 | 0.133407 | 7.20 | 270.66 |
| | 0.0252 | 0.903 | 0.0261 | 0.0009 | 0.133112 | 7.19 | 270.73 |
| 39 | 0.0246 | 0.899 | 0.0256 | 0.001 | 0.133704 | 8.02 | 302.19 |
| | 0.0257 | 0.903 | 0.0268 | 0.0011 | 0.133112 | 8.79 | 330.95 |
| | 0.0254 | 0.905 | 0.0266 | 0.0012 | 0.132818 | 9.56 | 360.18 |
| | 0.0252 | 0.905 | 0.0264 | 0.0012 | 0.132818 | 9.56 | 360.18 |
| 66.67 | 0.0218 | 0.893 | 0.0227 | 0.0009 | 0.134602 | 7.27 | 273.77 |
| | 0.0213 | 0.894 | 0.0222 | 0.0009 | 0.134452 | 7.26 | 273.50 |
| | 0.0211 | 0.895 | 0.022 | 0.0009 | 0.134302 | 7.25 | 273.16 |
| | 0.021 | 0.895 | 0.0218 | 0.0008 | 0.134302 | 6.45 | 242.85 |
| 150 | 0.0232 | 0.894 | 0.0239 | 0.0007 | 0.134452 | 5.65 | 212.67 |
| | 0.0236 | 0.896 | 0.024 | 0.0004 | 0.134152 | 3.22 | 121.255 |
| | 0.0235 | 0.899 | 0.0241 | 0.0006 | 0.133704 | 4.81 | 181.27 |
| | 0.0225 | 0.899 | 0.0231 | 0.0006 | 0.133704 | 4.81 | 181.27 |
| 231.12 | 0.0248 | 0.899 | 0.0253 | 0.0005 | 0.133704 | 4.01 | 151.09 |
| | 0.0258 | 0.901 | 0.0262 | 0.0004 | 0.133407 | 3.20 | 120.58 |
| | 0.0257 | 0.903 | 0.0262 | 0.0005 | 0.133112 | 3.99 | 150.41 |
| | 0.0255 | 0.904 | 0.0259 | 0.0004 | 0.132965 | 3.19 | 120.17 |

Table 4. Data evaluation for 3 m/s air velocity and different solutions

| Con. of the $CaCl_2$ solution (gm/kg water) | Specific humidity at inlet W1 (kg/kg of dry air) | Specific volume at inlet V ($m^3$/kg of dry air) | Specific humidity at exit W2 (kg/kg of dry air) | ($W_2$-$W_1$) | Mass of air supp. $m_a$ (kg/s) | Rate of water evaporation m (gm/min) | Cooling rate of desiccant cooling system H (W) |
|---|---|---|---|---|---|---|---|
| 32.67 | 0.0236 | 0.902 | 0.0248 | 0.0012 | 0.199889 | 14.39 | 542.13 |
| | 0.0234 | 0.9 | 0.0244 | 0.001 | 0.200333 | 12.02 | 452.74 |
| | 0.0231 | 0.9 | 0.0241 | 0.001 | 0.200333 | 12.02 | 452.74 |
| | 0.0233 | 0.902 | 0.0246 | 0.0013 | 0.199889 | 15.59 | 587.26 |
| 39 | 0.0244 | 0.906 | 0.0254 | 0.001 | 0.199007 | 11.94 | 449.77 |
| | 0.0244 | 0.906 | 0.0254 | 0.001 | 0.199007 | 11.94 | 449.77 |
| | 0.024 | 0.901 | 0.025 | 0.001 | 0.200111 | 12.01 | 452.27 |
| | 0.0229 | 0.897 | 0.0242 | 0.0013 | 0.201003 | 15.68 | 590.44 |
| 66.67 | 0.021 | 0.898 | 0.0219 | 0.0009 | 0.20078 | 10.84 | 408.36 |
| | 0.0209 | 0.899 | 0.0221 | 0.0012 | 0.200556 | 14.44 | 543.89 |
| | 0.0213 | 0.894 | 0.0222 | 0.0009 | 0.201678 | 10.89 | 410.18 |
| | 0.0208 | 0.892 | 0.0219 | 0.0011 | 0.20213 | 13.34 | 502.48 |
| 150 | 0.0221 | 0.899 | 0.0227 | 0.0006 | 0.200556 | 7.22 | 271.94 |
| | 0.0221 | 0.898 | 0.0226 | 0.0005 | 0.20078 | 6.02 | 226.88 |
| | 0.0223 | 0.897 | 0.0227 | 0.0004 | 0.201003 | 4.82 | 181.68 |
| | 0.0224 | 0.895 | 0.0229 | 0.0005 | 0.201453 | 6.04 | 227.62 |
| | 0.0265 | 0.908 | 0.027 | 0.0005 | 0.198568 | 5.96 | 224.38 |
| | 0.0265 | 0.91 | 0.0271 | 0.0006 | 0.198132 | 7.13 | 268.69 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 231.12 | 0.0255 | 0.904 | 0.02605 | 0.00055 | 0.199447 | 6.58 | 247.92 |
| | 0.0249 | 0.904 | 0.0254 | 0.0005 | 0.199447 | 5.98 | 225.39 |

## 5.2 Graphical Results

Figures 2 and 3 demonstrate the effect of air inlet-exit temperature variation on evaporation rate with day time for both 2 m/s and 3 m/s air velocity when the concentration of $CaCl_2$ solution is 32.67 gm/kg-water. From the graphical representation it is found that the water evaporation rate fluctuates with the air inlet and exit temperature difference. The temperature differences vary from 0.4-0.8$^0$C for the air velocity of 2m/s and from 0.5-1.2$^0$C for the air velocity of 3m/s. It has been shown that if the temperature difference increases then the water evaporation rate will also increase. But the evaporation rate decreases if the air inlet and exit temperature difference fall down for both 2m/s and 3m/s air velocities.

Comparing the figures 2 and 3 it is noted that due to increase in the velocity of the air the heat transfer rate to the air from the heat exchanger increases which increase the difference between air inlet and exit temperatures. If the difference between air inlet and exit temperature increases the regeneration of the solution will also increase. If the regeneration of the solution increases the water evaporation rate will also increase. It is also noticeable that due to the increase of the concentration of solution the evaporation rate decreases. The water inlet temperatures vary between 36 to 42$^0$C and the differences between water inlet and exit temperatures vary between 3 to 5$^0$C depending on the conditions of the environment and the velocities of the air to the desiccant regenerator.

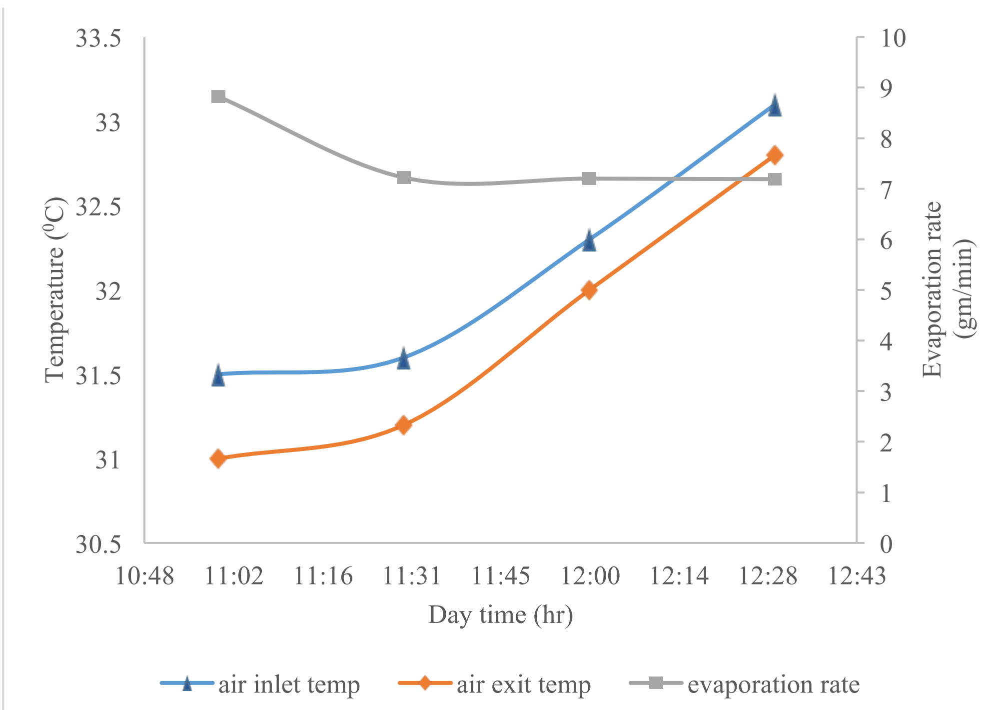



Figure 2. Effect of air inlet exit temperature variation on evaporation rate with day time for 2 m/s air velocity and 32.67 gm/kg water solution

The variation of water and air inlet and exit temperatures depend on the atmospheric conditions. If the atmosphere is cloudy then the differences between the water and air inlet and exit temperatures are low. On the other hand the condition of the air inlet temperatures depend on the efficiency of the radiator type heat exchanger. If efficiency is good the temperatures of air inlet also increase.

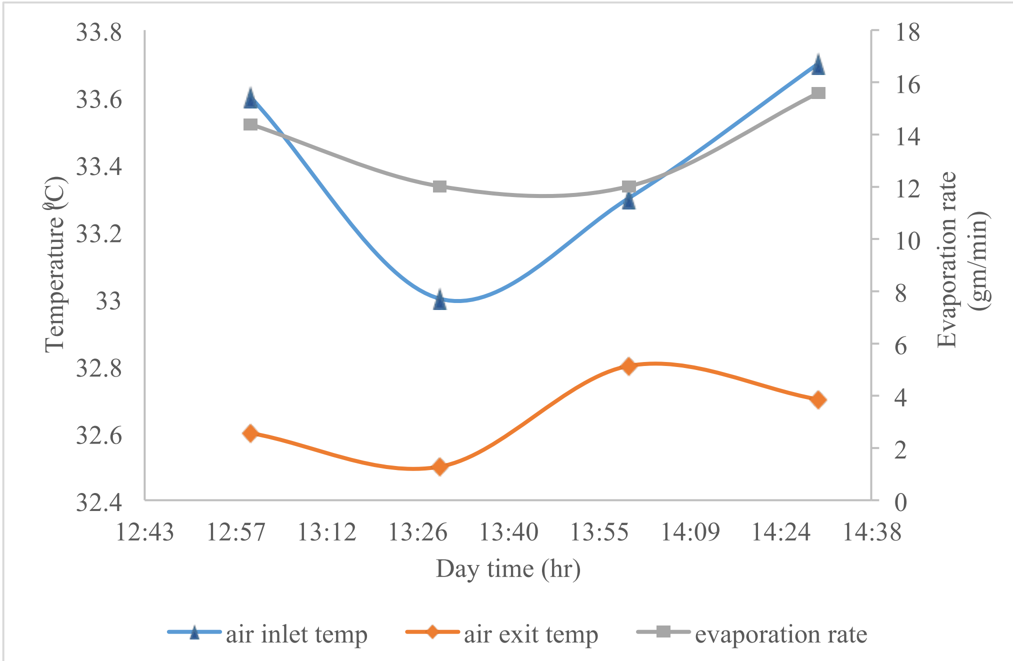



Figure 3. Effect of air inlet exit temperature variation on evaporation rate with day time for 3 m/s air velocity and 32.67 gm/kg water solution

In figures 4 and 5 variation of specific humidity at inlet and exit portion of the desiccant regeneration system with day time have been shown for both 2 m/s and 3 m/s air velocity when the concentration of $CaCl_2$ solution is 32.67 gm/kg-water. The figures show that the exit specific humidity is greater than the inlet specific humidity which means that during the regeneration process the inlet hot air to the desiccant regenerator extract water from the solution and humid air exit from the desiccant regenerator.

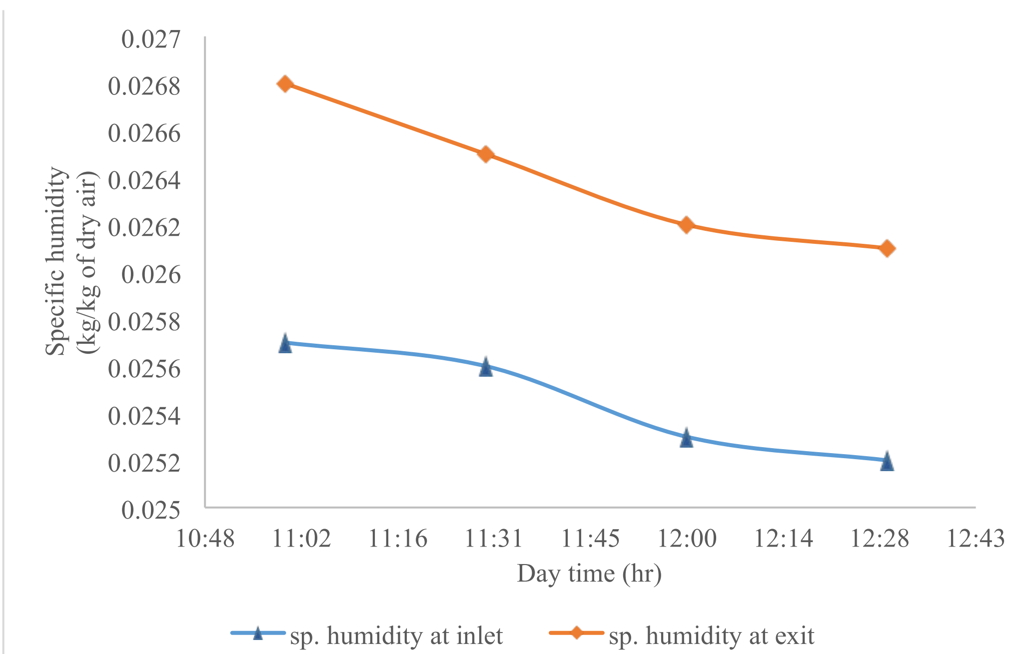



Figure 4. Variation of Specific humidity with day time for 2m/s air velocity and 32.67gm/kg water solution

This variation of specific humidity of the air depends on the temperature of the air and the concentration of the solution. From the figures for 4 and 5 it is found that due to the increase in air inlet and exit temperature difference the difference of exit and inlet specific humidity also increase and decrease with the decrease in air inlet and exit temperature difference. The temperature differences are different for various solution at various air velocity. So to compare the effect of concentration on evaporation and cooling rate for different air velocities the temperature difference has been taken as $0.6^0$C.

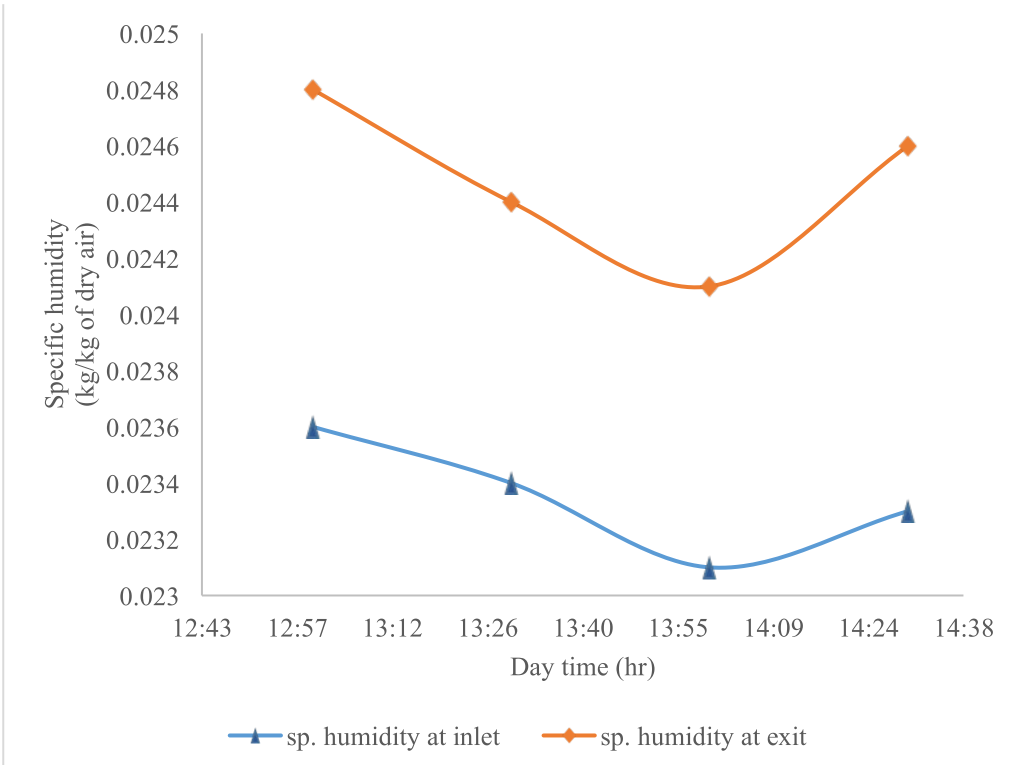



Figure 5. Variation of Specific humidity with day time for 3m/s air velocity and 32.67gm/kg water solution

In figure 6 effect of concentration on evaporation rate for different air velocity at air inlet and exit temperature difference of $0.6^0$C has been shown. From the figure 6 it is found that due to the increase in concentration the water evaporation rate from the $CaCl_2$ solution decreases for both 2m/s and 3m/s air velocities. It happens due to the decrease of vapor pressure when the inlet concentration is increased. It is also noticeable that the evaporation rate of the water increases with the increase in air velocity but also decreases with increase in concentration of the solutions. It has been shown that due to the increase of the air velocity the evaporation rate of water increases within the range of 25%-49.5% at air inlet and exit temperature difference of $0.6^0$C.
In figure 7 effect of concentration on cooling rate of desiccant cooling system for different air velocity at air inlet and exit temperature difference of $0.6^0$C has been shown. The cooling rate of desiccant cooling system decreases with the increase of the concentration of the solution. The cooling rate of the desiccant cooling system increase with the increase of the air velocity which has been shown in figure. It has been shown that due to the increase of the air velocity the cooling rate also increases within the range of 25%-49.5% at air inlet and exit temperature difference of $0.6^0$C.

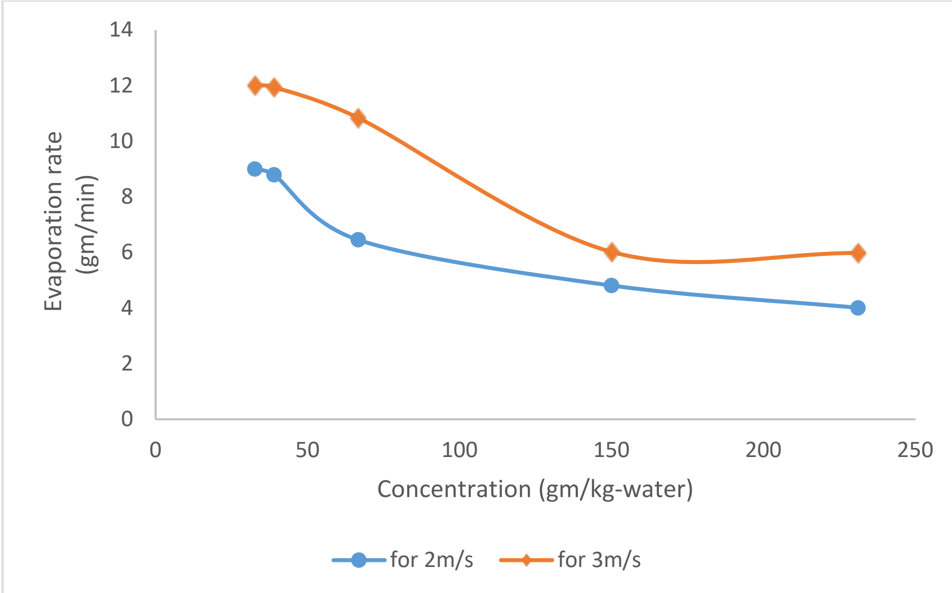



Figure 6. Effect of concentration on evaporation rate for different air velocity at $\Delta t=0.6^0C$

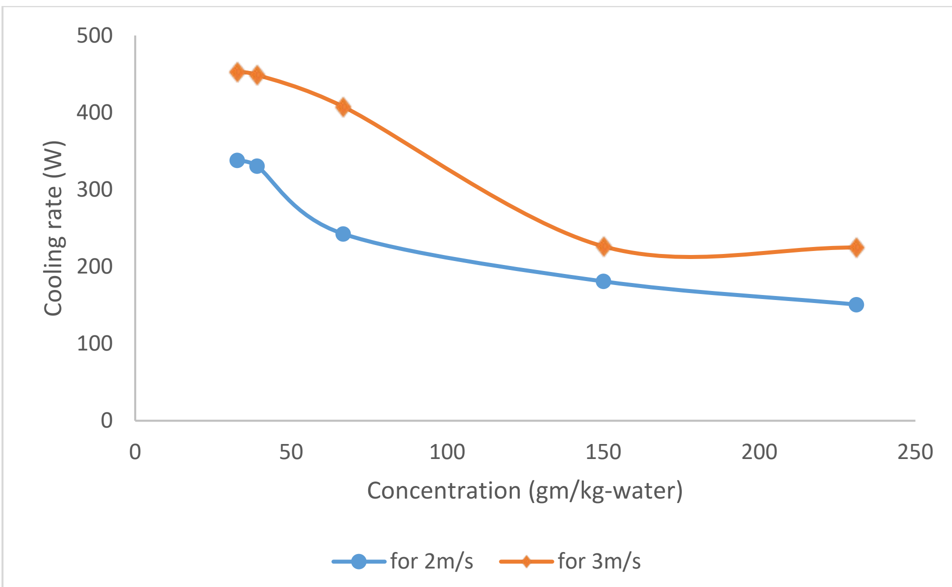
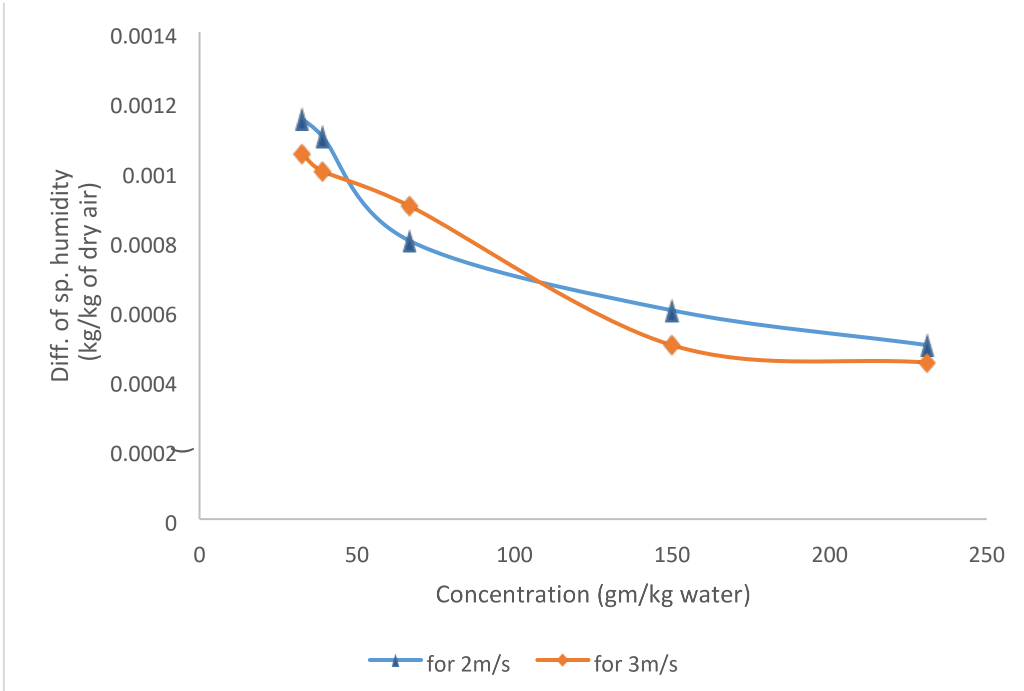



Figure 7. Effect of concentration on cooling rate of desiccant cooling system for different air velocity at $\Delta t=0.6^0C$

In the figure 8 the effect of the concentration on the difference of specific humidity for different air velocity at air inlet and exit temperature difference of $0.6^0C$ has been shown. It is found from the figure that due to the increase in concentration the difference of specific humidity gradually decreases. It is also noticeable that due to the increase in air velocity the difference of specific humidity at exit and inlet to the regenerator also decreases.




Figurer 8. Effect of concentration on the difference of specific humidity for different air velocity at $\Delta t=0.6^0C$

## 6. Conclusion

The goal of this experiment is to analyse the effect of different concentration of the $CaCl_2$ solution and air flow rate to the water evaporation rate from the solution and cooling rate of desiccant cooling system. Experimental analysis has been done for this goal. The outcomes of this analysis are given below

- The evaporation rate and cooling rate decrease with the increase in concentration of the $CaCl_2$ solution.
- The evaporation rate and cooling rate increase about 25% - 49.5% with the increase of the air velocity from 2m/s to 3m/s at $6^0C$ air inlet and exit temperature difference.
- Established a solar water heating framework combined with an air heater and air humidifier to regenerate the $CaCl_2$ system.
- The difference between inlet and exit specific humidity in the regeneration process gradually decreases with the increase in concentration.

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