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# AN EXPERIMENTAL STUDY ON SEPARATION OF WATER FROM THE ATMOSPHERIC AIR

**Anirudh K.G[1], Sikdar D C[2], Pavithra Valliappan[3], Subhranshu Dora[4], Sumit Jain[5]**
Department of Chemical Engineering,
Dayananda Sagar College of Engineering,
Bangalore, Karnataka, India
anirudhkrishnag@gmail.com, dulalsi@yahoo.co.in, pavinachu@gmail.com, dorasubbu92@gmail.com,
sumitjain1312@gmail.com

**Abstract— Without water, humans cannot live. Since time began, we have lived by the water and vast tracts of waterless land have been abandoned as it is too difficult to inhabit. At any given moment, the earth's atmosphere contains 4,000 cubic miles of water, which is just 0.000012% of the 344 million cubic miles of water on earth. Nature maintains this ratio via evaporation and condensation, irrespective of the activities of man.**

**There is a certain need for an alternative to solve the water scarcity. Obtaining water from the atmosphere is nothing new - since the beginning of time, nature's continuous hydrologic cycle of evaporation and condensation in the form of rain or snow has been the sole source and means of regenerating wholesome water for all forms of life on earth.**

**An effective method to generate water is by the separation of moisture present in air by condensation. In this study, the water present in air is condensed on the surface of a container and then collected in an external jacket provided on the container. Insulations are provided to optimize the inner temperature of the container.**

**The method is although uncommon but has certain advantages which make it a success. The process is economical and does not require a lot of utilities. It also helps in further reducing the carbon footprint.**

**Index Terms — Condensation, Humidity, Atmospheric Air, Water.**

## I. INTRODUCTION

Water is a transparent fluid which forms the world's streams, lakes, oceans and rain, and is the major constituent of the fluids of living things. As a chemical compound, a water molecule contains one oxygen atom and two hydrogen atoms that are connected by covalent bonds. Water is a liquid at standard ambient temperature and pressure, but it often co-exists on Earth with its solid state, ice; and gaseous state, water vapor.

Water covers 71% of the Earth's surface. It is vital for all known forms of life. On Earth, 96.5% of the planet's water is found in seas and oceans, 1.7% in groundwater, 1.7% in glaciers and the ice caps of Antarctica and Greenland, a small fraction in other large water bodies, and 0.001% in the air as vapor, clouds (formed of ice and liquid water suspended in air), and precipitation. Only 2.5% of the Earth's water is fresh water, and 98.8% of that water is in ice (excepting ice in clouds) and groundwater. Less than 0.3% of all freshwater is in rivers, lakes, and the atmosphere, and an even smaller amount of the Earth's freshwater (0.003%) is contained within biological bodies and manufactured products.

Water on Earth moves continuously through the water cycle of evaporation and transpiration, condensation, precipitation and runoff, usually reaching the sea.

Safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrients. Access to safe drinking water has improved over the last few decades in almost every part of the world, but approximately one billion people still lack access to safe water. There is a clear correlation between access to safe water and gross domestic product per capita. However, some observers have estimated that by 2025, more than half of the world population will be facing water-based vulnerability. As per the report given by Geological Survey of India in November 2009, that by 2030, in some developing regions of the world, water demand will exceed supply by 50%. Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. Approximately 70% of the fresh water used by humans goes to agriculture.

Water scarcity is the lack of sufficient available water resources to meet the demands of water usage within a region. It has already affected every continent and around 2.8 billion people around the world. More than 1.2 billion people lack access to clean drinking water.

Water scarcity involves water stress, water shortage or deficits, and water crisis. While the concept of water stress is relatively new, it is difficult to obtain sources of fresh water for use during a period of time and may result in further depletion and deterioration of available water resources. Water shortages may be caused by climate change, such as altered weather patterns including droughts or floods, increased pollution, and increased human demand and overuse of water. A water crisis is a situation where the available potable, unpolluted water within a region is less than that region's demand. Water scarcity is driven by two converging phenomena: growing freshwater use and depletion of usable freshwater resources.

The main objective of this study is to separate water from atmospheric air which in turn will reduce the water scarcity of the society.

## II. MATERIALS AND METHODS

### A. *Materials/Instruments Used*

The materials/instruments used for this work are, a fabricated stainless steel condensation unit. , thermometer (0 to 100˚C), an iron stand and sample collection containers.

### *B. Preliminary processing of raw materials*

A stainless steel container is taken for conducting trials alongside glass container. Care is taken such that both the containers approximately have the same surface area. Both containers are filled equally with medium sized ice cubes. Three layers of insulation are provided: NaCl, rice husk, and gunny covers. Collection vessels are placed under both the containers. For a period of 2.5 hours both the containers are kept under observation. It is seen that conduction didn't occur properly in the glass container because of high resistance. Hence stainless steel is chosen as the appropriate material for fabrication of the condensation unit.

**Fig.1 Preliminary Experiment on Condensation**

*C. Process of Condensation*

Water can be generated by utilizing the moisture present in air via condensation. A Stainless Steel cylindrical container which is closed on one end and open on the other is taken. Any source of available cold water is filled inside the container. The open end of the container is tightly covered with a muslin cloth and the container is suspended upside-down from any surface.

**Fig 2: Condensation Unit**

Due to the presence of tiny pores in the cloth, the droplets of water present in these pores come in contact with air, get cooled and move upward giving way to a different set of water droplets. This way the temperature of the entire volume of water inside the container is much lesser compared to the surrounding atmospheric air. The setup is left ideal for about 2.5 hours, at the end of which there is a drop in temperature by 5-6 degrees. To further cool down the water, about 150 gm of ice cubes is added. The difference between the higher temperature of the atmosphere and lower temperature inside the container leads to the condensation of the moisture present in the air which in turn leads to the formation of water droplets on the outer surface of the container which is then collected.

The procedure is repeated in three different places at different weather conditions. The samples of water collected are shown in Fig 3.

Water properties such as total acidity, total alkalinity, dissolved oxygen, chemical oxygen demand (COD) are determined by standard methods.

**Fig 3: Samples of water collected**

## III. RESULTS AND DISCUSSION

*A. Observation and Collection of Water Sample (Preliminary) in Bangalore:*

It is observed from the Table1 that in Bangalore for the day temperature 27°C, humidity 55% and weather condition sunny, the amount of water sample (preliminary) collected using same size of glass and stainless steel container are 5 and 8ml respectively for a time period of 150 minutes. The stainless steel container is observed to separate more amount of water sample from the atmospheric air rather than the glass container. This is due to the difference in thermal conductivities of the containers' material. Hence stainless steel is chosen as the appropriate material for fabrication of the condensation unit.

| | |
|---|---|
| Start time | 01:30 pm |
| End time | 04:00 pm |
| Time Duration (mins) | 150 |
| Temperature (°C) | 27 |
| W.B.T. (°C) | 20 |
| Weather condition | Sunny |
| Chemical used | NaCl |
| Humidity (%) | 55 |
| Amount of water collected (ml) | 49 |

**Table 1.Observation of preliminary trial**

A plot of volume of water collected v/s time is shown in Fig. 4 for glass & Fig. 5. for stainless steel.

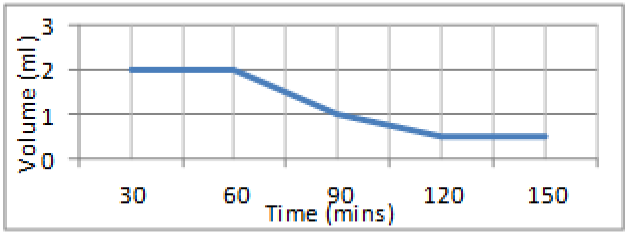


**Fig. 4.Plot of Volume v/s Time**

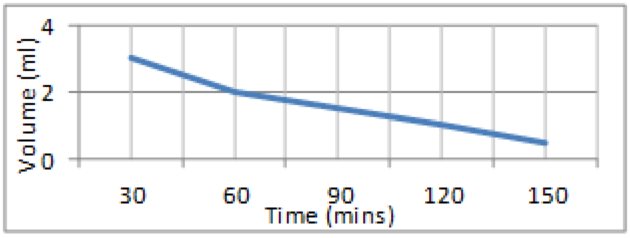


**Fig. 5.Plot of Volume v/s Time**

*B. Observation and Collection of Water Sample in Bangalore:*

The observation and collection of water samples from the atmospheric air are as follows:

| | |
|---|---|
| Start time | 01:30 pm |
| End time | 04:00 pm |
| Time Duration (mins) | 150 |
| Temperature (°C) | 27 |
| W.B.T. (°C) | 20 |
| Weather condition | Sunny |
| Chemical used | NaCl |
| Humidity (%) | 55 |
| Amount of water collected (ml) | 49 |

**Table2. Observation and collection of water sample 1 in Bangalore**

It is observed from the Table 2 that in Bangalore for the day temperature 27°C, humidity 55% and weather condition sunny, the amount of water sample collected is 49ml for a time period of 150 minutes. A plot of volume of water collected v/s time is shown in Fig 6.

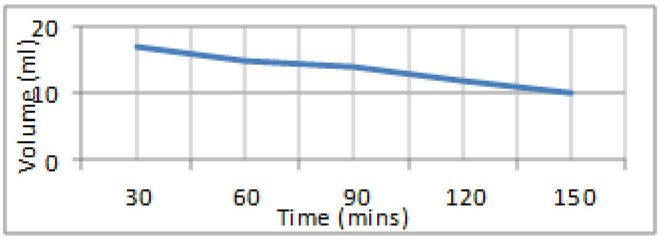


**Fig. 6.Plot of Volume v/s Time**

| | |
|---|---|
| Start Time | 01:30 pm |
| End Time | 04:00 pm |
| Time Duration (mins) | 150 |
| Temperature (°C) | 27 |
| W.B.T. (°C) | 22 |
| Weather Condition | Cloudy |
| Chemical Used | NaCl |
| Humidity (%) | 61 |
| Amount Of Water Collected (ml) | 55 |

**Table 3. Observation and collection of water sample 2 in Bangalore**

It is observed from the Table 3 that in Bangalore for the day temperature 27°C, humidity 61% and weather condition cloudy, the amount of water sample collected is 55ml for a time period of 150 minutes. A plot of volume of water collected v/s time is shown in Fig 7.

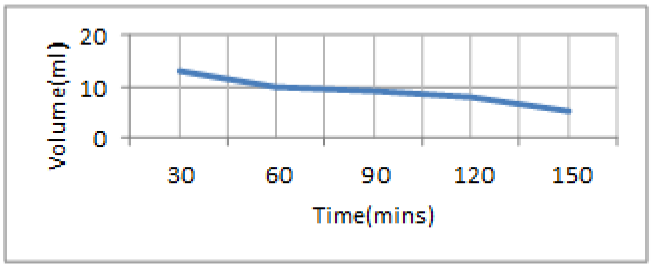


**Fig. 7. Plot of Volume v/s Time.**

| | |
|---|---|
| Start time | 10:00 am |
| End time | 12:30 am |
| Time Duration (mins) | 150 |
| Temperature (°c) | 29 |
| W.B.T. (°c) | 23.5 |
| Weather condition | Passing cloud |
| Chemical used | $Na_2S_2O_3$ |
| Humidity (%) | 67 |
| Amount of water collected (ml) | 68 |

**Table 4. Observation and collection of water sample 3 in Bangalore**

It is observed from the Table 4 that in Bangalore for the day temperature 29°C, humidity 67% and weather condition passing cloud, the amount of water sample collected is 68ml for a time period of 150 minutes. A plot of volume of water collected v/s time is shown in Fig 8.

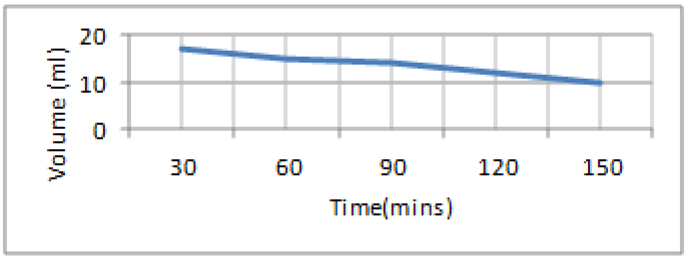


**Fig. 8. Plot of Volume v/s Time.**

*C. Observation and Collection of Water Sample in Hyderabad:*

The observation and collection of water sample from the atmospheric air is as follows:

| | |
|---|---|
| Start time | 01:00 am |
| End time | 03:30 pm |
| Time Duration (mins) | 150 |
| Temperature (°C) | 41 |
| W.B.T. (°C) | 25.5 |
| Weather Condition | Partly cloudy |
| Chemical Used | NaCl |
| Humidity (%) | 30 |
| Amount Of Water Collected (ml) | 40 |

**Table 5. Observation and collection of water sample in Hyderabad**

It is observed from the Table 5 that in Hyderabad for the day temperature 41°C, humidity 30% and weather condition partly cloudy, the amount of water sample collected is 40ml for a time period of 150 minutes. A plot of volume of water collected v/s time is shown in Fig 9.

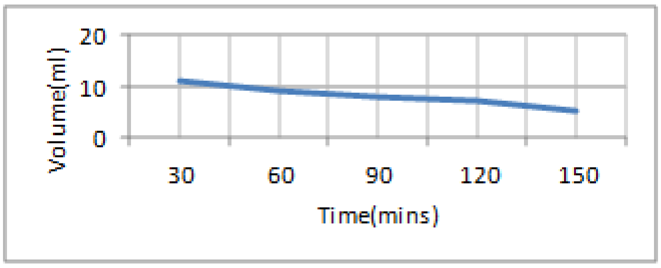


**Fig. 9. Plot of Volume v/s Time**

D. Observation and Collection of Water Sample in Coimbatore:

The observation and collection of water sample from the atmospheric air is as follows:

| | |
|---|---|
| Start Time | 07:00 am |
| End Time | 09:30 am |
| Time Duration (mins) | 150 |
| Temperature (°C) | 23 |
| W.B.T. (°C) | 21.5 |
| Weather Condition | Haze |
| Chemical Used | NaCl |
| Humidity (%) | 83 |
| Amount Of Water Collected (ml) | 71 |

**Table 6. Observation and collection of water sample in Coimbatore**

It is observed from the Table 6 that in Coimbatore for the day temperature 23°C, humidity 83% and weather condition hazy, the amount of water sample collected is 71 ml for a time period of 150 minutes. A plot of volume of water collected v/s time is shown in Fig 10.

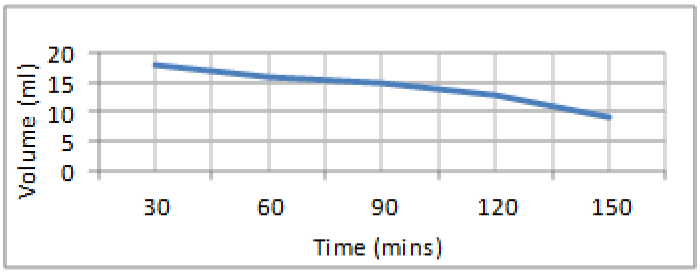


**Fig. 10. Plot of Volume v/s Time**

*D. Heat Balance*

The result obtained for water sample 2, collected in Bangalore, is verified by the following equation:

Rate of Heat In = Rate of Heat Out

$\mathbf{m1\lambda = m2Cp\ \Delta T}$

Where m1= amount of water collected = 55*10-3 kg

λ= latent heat of vaporization = 2240 kJ/kg

m2= mass of the container = 6.5 kg

Cp = specific heat of water = 4.187 kJ/kg K

ΔT= difference between outside and inside (the container) temperature

=> **16.3W ≈ 18W**

*E. Determination of Water Qualities and Comparison*

Test 1: Determination of Alkalinity

Phenolphthalein alkalinity:

100 ml of the sample is taken in a conical flask and 2-3 drops of phenolphthalein indicator are added. If the solution remains colorless, the phenolphthalein alkalinity is zero. If the colour changes to pink after the addition of indicator, it is titrated with 0.1N HCl until the colour disappears at the end point. The end point is pink to colorless. The amount of HCl used is noted down.

Total alkalinity:

To the same sample 2-3 drops of methyl orange indicator are added and titration is continued until the yellow colour changes to pink. The burette reading which gives the volume of HCl is noted down.

Test 2: Determination of Chemical Oxygen Demand (COD)

0.4 gm of HgS04 is placed in a reflux flask and 20 ml of the sample diluted to 50 ml using distilled water is added to it. Glass beads are added followed by 50 ml std. $K_2Cr_2O_7$.70 ml $H_2SO_4$ containing $Ag_2SO_4$ is added, mixing thoroughly along cooling. Similarly another flask is taken and blank titration is carried out using distilled water in place of sample. Both the flasks are connected to the condenser separately and the contents are mixed before heating. Reflux for a minimum period of 2 hours is carried out and the condenser is cooled and washed with distilled water. It is diluted with 150ml cold water and excess $K_2Cr_2O_7$ is titrated against 0.25N FAS using ferroin indicator. A sharp colour change from blue green to reddish brown indicates the end point.

Test 3: Analysis of Dissolved Oxygen

The BOD bottles are filled with the given sample up to the neck. Air bubbles are avoided. 2ml of $MnSO_4$ and 5ml of alkaline potassium iodide solution are added separately at the bottom of the bottle. The contents of the bottle are mixed well by inverting the bottle a few times. Precipitation will appear. After the precipitate has settled to about 1/3rd the volume of the bottle from the bottom, 2ml of concentrated Sulphuric acid is added. Once again the contents are mixed gently till the suspension is completely dissolved and a uniform yellow colour solution is obtained.50 ml of this solution is taken in a conical flask and around 1ml of starch is added and titrated with 0.25N $Na_2S_2O_3$. The end point is dark blue to colorless.

Test 4: Determination of Acidity

50 ml of the water sample is taken in a conical flask.2-3 drops of phenolphthalein indicator are added and mixed well. The solution is titrated against 0.05N NaOH solution taken in burette until the permanent pink colour just appears. Burette reading is noted down.

| Test | Tap water | Sample water | Mineral water | BIS Specifications |
|---|---|---|---|---|
| Phenolphthalein alkalinity (mg/l) | 0 | 0 | 0 | 0 |
| Total alkalinity (mg/l) | 562.5 | 210.5 | 195 | 200 |
| Total acidity(mg/l) | 994 | 280 | 266 | 200 |
| COD (mg/l) | 249 | 210 | 200 | 200 |
| Dissolved oxygen (mg/l) | 5.2 | 6 | 7.6 | 6 |

**Table 7: Comparison of Water Qualities**

Table 7 gives the comparison of water qualities of tap, sample and mineral water with the BIS specification for potable water. It is seen that the sample water when compared to tap water is better and it almost meets the BIS specification for potable water.

## IV. CONCLUSION

The separation of water from atmospheric air was feasible in lab scale. The maximum amount of water collected in Bangalore was 68ml for a period of 150 mins, at a temperature of 29 °C, humidity of 63%, wet bulb temperature of 23 °C, and the weather was partly cloudy. The maximum amount of water collected through the course of the project was in Coimbatore, a volume of 71 ml for a period of 150mins, at a temperature of 23 °C, humidity 83%, wet bulb temperature of 21.5 °C was collected, and the weather was hazy. Minimum amount of water collected through the course of the project was in Hyderabad, a volume of 40 ml for a period of 150mins, at a temperature of 41 °C, humidity 30%, wet bulb temperature of 25.5 °C was collected, and the weather was partly cloudy. It is observed that humidity has the major affect in collection of water.The amount of water collected in the lab scale is comparatively less. In case cryogenic liquids such as liquid nitrogen are used, the ΔT value can be increased enormously and hence a large amount of water can be collected. And by this way, the water scarcity problem can be overcome to some extent, by the separation and collection method.

## V. ACKNOWLEDGEMENT

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