Knowledge Corner

Can solar-based atmospheric water harvesting be a potential method for collecting water in Thar Desert of Rajasthan?

Atmospheric Water Harvesting

In arid regions, abrupt changes (or shifts) and gradual changes (or trends) causing the rainfall variability over the temporal and spatial scales have profound influence on the dynamic linkages between ecosystems and water cycle mainly due to the limiting water resources, which is constrained not only for scarce quantities but also for its intermittency and unpredictable nature. Studies on analyzing rainfall variability are of high importance for the arid regions. However, such studies are mostly carried out in humid and semi-arid regions, and the studies for arid regions are rare. The issues of water-shortages and water scarcity can be easily tackled by rainwater harvesting techniques, which is being practiced from the historical times all over the world. However, under the extreme aridity conditions and failure of monsoon rains, such methods have limitations of dependence on occurrence of rainfall (Fig.6).

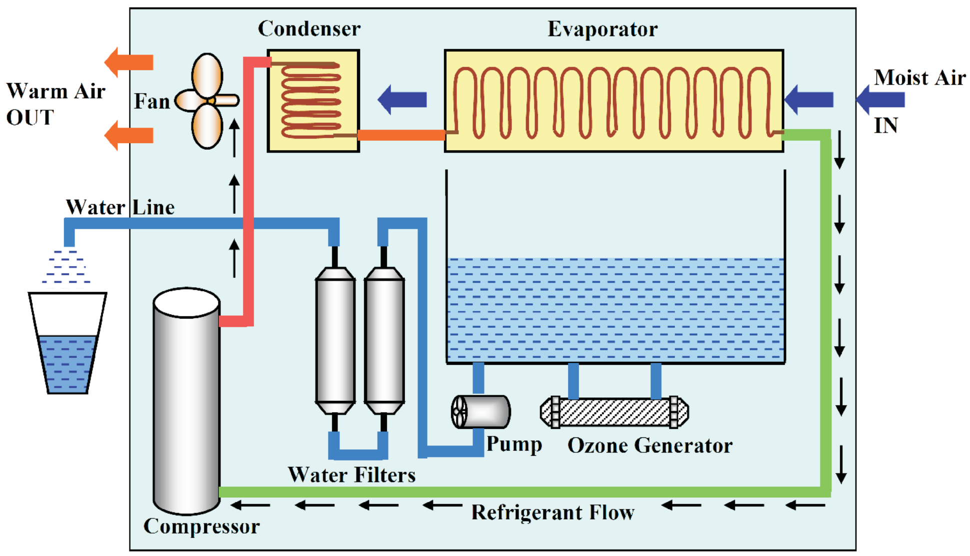

Fig. 6. Schematic of Conventional Atmospheric Water Harvesting System

Atmospheric water harvesting (AWH) is relatively a new concept where moisture available in the atmospheric air is extracted by condensation process and is converted to water. The AWH is one of the promising alternative methods for getting pure water in dry regions especially where relative humidity remains in high amounts in the atmospheric air such as coastal arid lands and similar regions. It is estimated that a plenty of water (12,900 billion tons) is available in the atmosphere even in very dry desert regions, and the atmospheric water, consisting of water vapour and water droplets, is a resource equivalent to about 10% of all freshwater in lakes and is 6 times all water in rivers on Earth. Therefore, atmospheric water is currently captured in remote villages of more than 25 countries worldwide, for example, Chile, China, Egypt, India, Israel, Republic of Korea, Saudi Arabia, Spain, among others.

Water from air can be collected through several ways, for example, fog harvesting, dew harvesting through active/passive refrigeration, and sorption in conjunction with easily accessible low-grade energy. Fog harvesting is considered as the ancient method, where water droplets floating in the air are directly collected. However, this method needs a constantly high ambient relative humidity (~100%), and thus, it is feasible only in very limited areas. In refrigeration method, an engineered cold surface is used to cool adjacent air mass below the dew point to produce water droplet through condensation. In general, it is observed that refrigeration is not feasible in regions experiencing either consistently low relative humidity (<40%) or lack of electricity. The sorption-based method is also a method that employs water sorbent to absorb water vapor from air, followed by heating up the saturated sorbent to release and subsequently condense the water. A major advantage of the sorption-based method over the other methods is its capability of producing water from dry air with humidity even lower than 20% in the absence of electricity.

Principle of Extracting Moisture from Atmosphere

A large amount of water always remains available in the atmosphere in the form of water vapour, moisture, etc. and it is estimated that 30% of that water is usually wasted. Many different type of air water generators have been designed and fabricated to extract that amount of water from air. The water extracted by the AWH technique can be directly used even for drinking purpose as it is pure. The AWH method uses the principle of latent heat to convert water vapour molecules into water droplets. The concept of AWH is relatively new although rapid developments are being made in the field of AWH using many different materials for extracting water from the atmosphere. Initially, it was felt that AWH may be successful only in the areas where adequate relativity humidity exists in the atmospheric air. However, later on, advances in AWH technique made it possible to extract the air even in the regions having low relative humidity. Presently, technique is available to harvest water from the air of desert regions having very low relative humidity. In many countries like India, there are regions of extreme aridity such as Thar Desert where resources of water are limited. At those places, the AWH method is looked as the prospective solution of water scarcity. Previously, many researchers worldwide used the concept of air condensation as well as generation of water with the help of Peltier devices, such as harvesting water for trees using Peltier plates that are powered by solar energy, etc (Fig. 7).

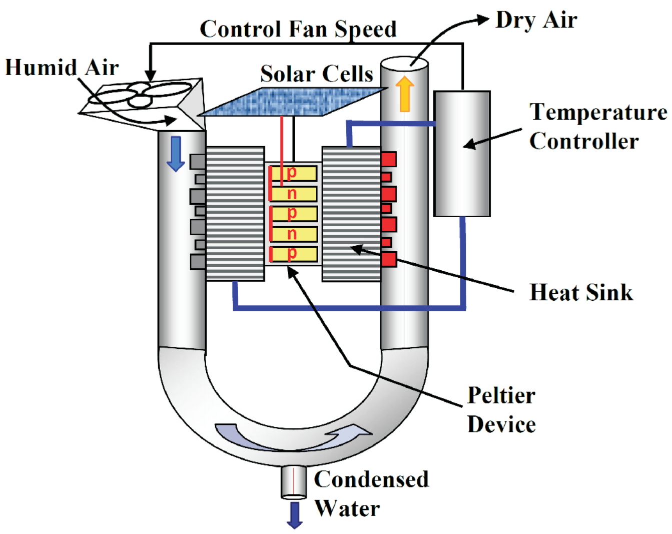

Fig. 7. Schematic of Atmospheric Water Harvesting System with Peltier Effect Powered by Solar Energy

Water is condensed at dew point temperature, which is practically achieved with the help of some electronic devices such as a thermoelectric Peltier couple. The thermoelectric Peltier couple is used to create the environment of water condensing temperature or dew point. A conventional compressor and evaporator system may also be used to condense water by simply exchanging the latent heat of coolant inside the evaporator. Recently, AWH method is combined with solar-thermal process along with effective water vapor sorbent. This type of AWH system is fully solar energy-driven, and thus, is also cost-effective in a long run.

Low Relative Humidity and High Energy Requirements

Since the water potential in atmosphere is about -100 to -500 bar, the AWH system need to be designed in such a way that water potential in the AWH system remains less than -500 bar to enable water moving from high to low water potential side. In nature, water flows either through soil to plant and then to atmosphere or directly from soil/free water body to atmosphere. This is because water potential remains about -0.3 bar in soil at field capacity, -1 to -3 bar in stem and -15 to -20 bar at leaf of the plant. Thus, water flows from high (soil) to low (plant leaf) water potential. Similarly, decreasing relative humidity in atmosphere increases the atmospheric water demand or in other terms decreases water potential in atmosphere. In arid region of western Rajasthan, relative humidity usually remains very low, which may pose difficulty in extracting moisture from the atmosphere as water needs to be flowed in opposite direction of natural flow in the proposed AWH system. Therefore, a large amount of energy may be required to follow the pathway against the natural flow direction of the water. Future studies evaluating feasibility and economics of the AWH system in arid regions of Western Rajasthan may further enlighten scope of solar energy in operating the AWH system.

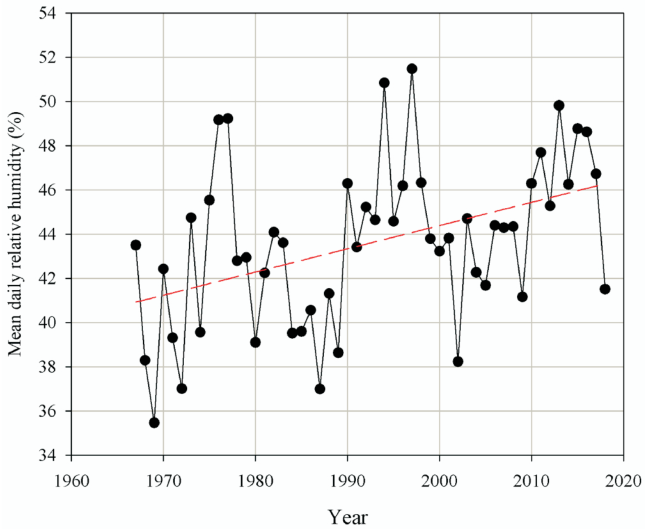

Fig. 8. Mean Daily Relative Humidity at Jodhpur over 52-Year (1967-2018) Period

Analysis of 52-year (1967-2018) relative humidity data collected from Meteorological Observatory of ICAR-Central Arid Zone Research Institute, Jodhpur revealed an increasing linear trend in the mean daily values of relative humidity (Fig. 8). Subsequently, lesser energy would be needed in extracting moisture from the atmospheric air experiencing increasing relative humidity. Thus, there exists a fair scope for utilizing the solar energy under the extreme climatic conditions of the Thar Desert in western Rajasthan for extracting the water from atmosphere.

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Events by ENVIS CAZRI

RE-ENVIS 2019

Seminar on Climate Change and Desertification: Renewable Energy Solutions for Enhancing Mitigation potential in Rajasthan

ICAR- CAZRI, ENVIS Centre on Combating Desertification, Jodhpur and The Energy and Resources Institute (TERI), New Delhi jointly organized seminar on "Climate Change and Desertification: Renewable Energy Solutions for Enhancing Mitigation Potential in Rajasthan" on 10th January, 2019 at Jaisalmer. Dr. Anandi Subramanian, Principal Advisor, Ministry of Environment, Forest & Climate Change, GOI in her inaugural address as chief guest stressed about various facts and facets of desertification and its control including effective strategies. Dr. Devi Dayal, Head, CAZRI-Regional Research Station, Bhuj, Gujarat in his presidential address talked about maladies of climate change and application potential of renewable energy in its mitigation.