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Review of Water Extraction From the Atmosphere

Ajithkumar V , Ravichandran P , Poongothai S
Annamalai University

***1Abstract*:- Fresh water is vital to life and yet it is a finite resource. Of all the water on Earth, just 3% is fresh water. Water is an amazing element. It is unique because it can be naturally found as a solid, liquid or gas. As lakes, oceans, rivers and streams increase in temperature, some water will change from liquid to gas, collecting together into clouds of moisture. As these clouds float over cooler seas or land, some of the moisture falls as rain or snow. This paper covers the research based on extraction of water from the atmospheric air. The key target in all these approaches is the enlargement of an water collected from an atmosphere that can produce water in low cost and can be made using cheap local materials.**

2.INTRODUCTION:

One sq.km of atmospheric air contains 10,000 to 30,000 m3 of pure water. Water is second to oxygen as being essential for life. People can survive days, weeks, or even longer without food, but only about four days without water. Globally, at least 2 billion people use a drinking water source contaminated with faeces. Microbial contamination of drinking-water as a result of contamination with faeces poses the greatest risk to drinking-water safety. Drinking water is never pure. Water naturally contains minerals and microorganisms from the rocks, soil, and air with which it comes in contact. Human activities can add many more substances to water. But drinking water does not need to be pure to be safe. In fact, some dissolved minerals in water can be beneficial to health. Four billion people almost two thirds of the world's population experience severe water scarcity for at least one month each year. Over two billion people live in countries where water supply is inadequate .Half of the world's population could be living in areas facing water scarcity by as early as 2025.Some 700 million people could be displaced by intense water scarcity by 2030. By 2040, roughly 1 in 4 children worldwide will be living in areas of extremely high water stress.

3.ATMOSPHERIC FOG HARVESTING:

A design of fog collector has been designed by Choiniere-Shields (fig 1). The concept of cloud harvester is based on a fog catcher that turn the condense fog into water droplet. The design of cloud harvester uses stainless steel mesh for the water collection. The Stainless steel mesh kept outside during night time, the metal surface becomes colder than air. The fog on the atmospheric air gathered on the stainless steel mesh collect on water storage container. The Fog harvester has a potential water harvesting output of one litre of fresh water per hour for each 10 square feet of mesh.

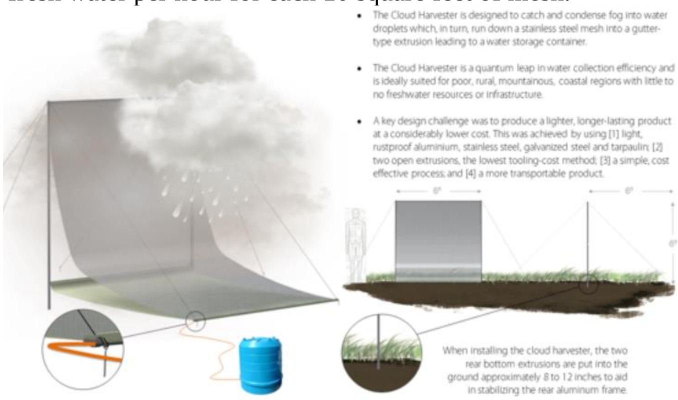

Fig 1 Stainless steel fog collector

4.ATMOSPHERIC WATER HARVESTING:

A.E.Kabeel *et al* ., described a glass pyramid shape with a multi-shelf solar system to extract water from atmospheric air (fig 2) collector with desiccant beds contain saw dust and 30% saturated concentrated calcium chloride cloth bed on shelves and a wall built of aluminum and glass faces the glass is 5mm thick which is slanting like pyramid and a collection cone at the top and a condenser section mounted on top of the pyramid, shading it from solar radiation. The height of the pyramid is 160cm,and the base is 100cm x 100cm. The covers over the beds are open overnight so the desiccant can absorb water vapor from the air. During the day, the covers are closed so the beds are heated by solar radiation driving off the absorbed water, which condenses on the sides and especially at the pyramid top, where it is collected by a central cone and flows through a tube to an external container. The reported water yield is 2.5 l/day/m^3; the cloth bed showed better performance than the sawdust bed system.

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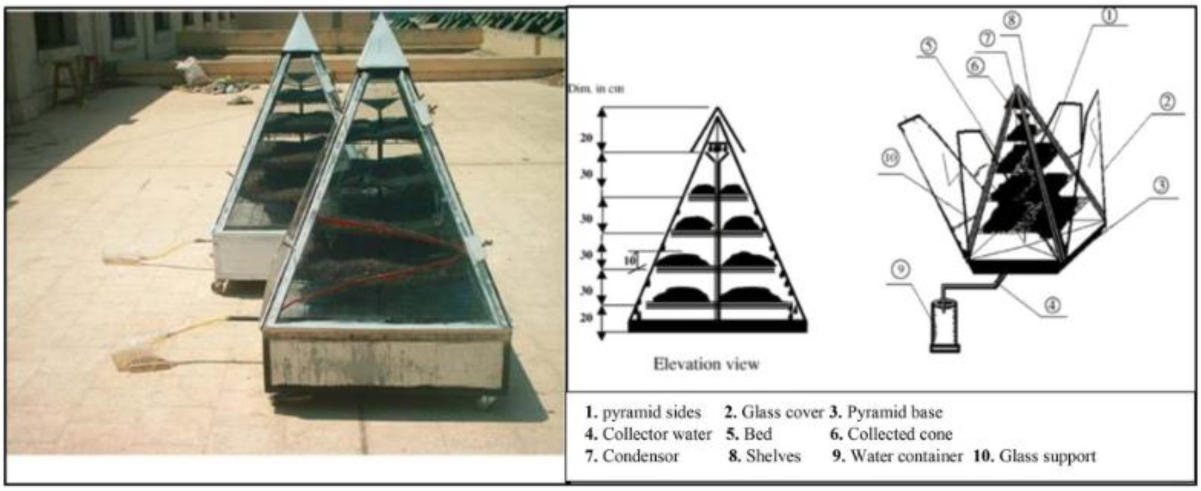

Fig 2 a glass pyramid shape with a multi-shelf solar system

William *et al* ., designed a trapezoidal prism solar collector with four sides with $CaCl_2$ as the desiccant supported on sand and on dark cloth (fig 3). The height of the collector is 1800 mm and the base dimensions of the test rig are 1000 mm × 1000 mm. The trapezoidal prism worked in essentially the same way as the pyramidal system described above in that moisture absorption occurred at night time and the solar radiation driving off the absorbed water during the day with the evaporated water forming water droplets that collected in the water tank. The fibre glass bolted to aluminum frames was used while the top of the prism was an opaque material that acted as a condenser and to facilitate collecting the condensate water. The efficiency was computed on day time by considering the total heat of evaporation to the total incident solar radiation. The results revealed that the total evaporated water for cloth and sand bed can reach 2.32 and 1.23 slit/days m^2 at initial saturation concentration (30%) of $cacl_2$. However, the system efficiency is 29.3 and 17.76% for cloth and sand bed, respectively.

No	Description
1,2,3	Temperature measuring points in each fibreglass side
4	Thermocouple selector switch position
5	Roof surface remperature measuring point
6	Top bed temperature measuring points
7	Middle bed temperature measuring points
8	Bottom bed temperature measuring points
9	Collecting surface for condensed droplets
10	Collected water tank

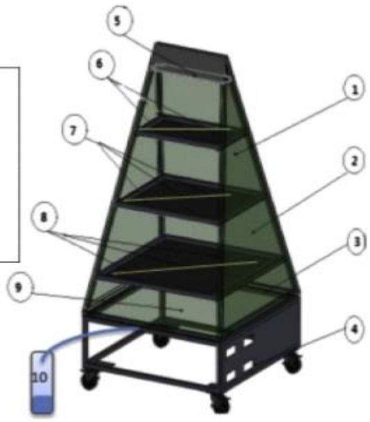

Fig 3 Desiccant system for water production from humid air using solar energy

The zirconium-based MOF-801 crystals pressed into a thin sheet of porous copper metal (fig 4). That sheet is placed between a solar absorber and a condenser plate and positioned inside a chamber. At night the chamber allowing ambient air to diffuse through the porous MOF and water molecules to stick to its interior surfaces, gathering tiny droplets. In the morning the sunlight entering on top of the device then heats up the solar absorber , the MOF which liberates the water droplets and drives them as vapour toward the cooler condenser. The temperature difference, as well as the high humidity inside the chamber, causes the vapour to condense as liquid water, which drips into a collector. The setup works so well that it pulls 2 .8 liters of water out of the air per day.

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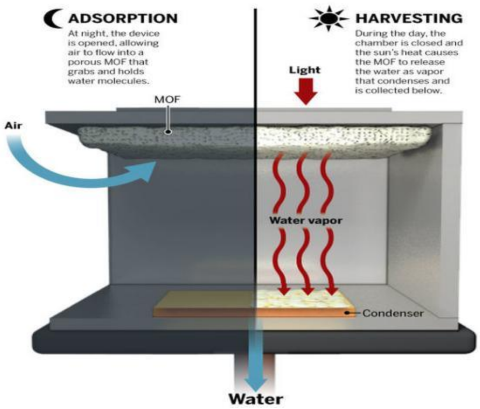

Fig 4 MOF porous metal-organic framework-801

The Air Drop irrigation system (fig 5), designed by Edward Linacre is also very inspiring. Ed linacre's airdrop is a simple device that literally sucks water out of thin air. Airdrop consists of a mast-like tube with a wind-powered turbine that sucks air down into a coiled metal pipe. The air descends under the earth and cools until it hits 100% humidity and the water starts to drip out. Linacre installed one in his mother's back yard in Australia and it pulled out a liter of water in a day. The units also have storage tanks, from where they pump out the water into underground irrigation systems.

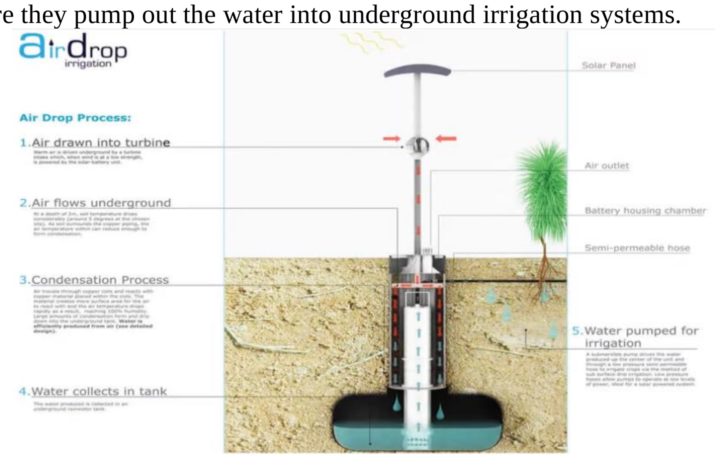

Fig 5 The Air Drop irrigation system

Beetle-Inspired Bottle (Dew bank) (fig 6) Which is made of stainless steel metal is used for extracting water from the atmosphere because during the night time surface become colder than air. The metal is in the shape as hemisphere with uneven form creates more dewdrops by widening superficial area of air and also contain narrow gap with the size to permit only water drops prevents the contamination by foreign materials and protect waters from wildlife. The stainless steel gathers water from air which is rolled to the lower part along slope surface by generating dew drops. The dew bank bottle is inspired from the insect called African Namibian desert beetle which collect water from the atmospheric air by perching in an opportune position that allows dew droplets to collect in ridges on its back.

Fig 6 Beetle-Inspired Bottle (Dew bank)

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A Billboard That Condenses Water From Humidity (fig 7). Atacama Desert is one of the driest places on earth, Lima, Peru. The desert receives almost no rainfall. Electricity from the city's power lines runs the condensers inside the billboard. When air contacts the cooled surfaces of the condensers, the air also cools, and the water vapor in the air condenses into liquid water. The billboard generates about 96 liters of water each day. Last December, they erected a billboard in the Bujama District of Lima that by early March had produced 9450 liters of water.

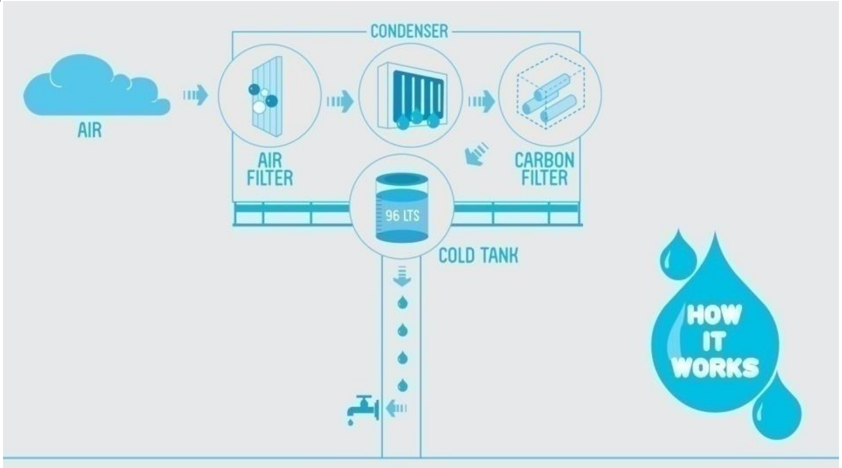

Fig 7 Billboard That Condenses Water From Humidity

Kaijie Yang *et al.*, extract water from the atmosphere and also produce electricity using a hygroscopic (G-PDDA) aero gel (fig 8), they design and fabricate a hygroscopic aero gel material that integrates a cationic polymer, poly(diallyl dimethyl ammonium chloride) (PDDA), and a negatively charged reduced graphene oxide (rGO), to produce a highly porous structure. In this aero gel (denoted as G-PDDA), the cationic polymer provides a large number of water harvesting sites, and the rGO acts as an effective solar thermal material. At the same time, the highly porous structure greatly facilitates the transfer of water and heat. The dual-function system achieves this by combining AWH with thermoelectric technology and using natural sunlight as the sole energy input. The model system can produce a maximum output power density of 6.6 mW/m^2 during the moisture capture process at the relative humidity of 60%, and 520 mW/m^2 during the water release process under 1 kW/m^2 solar irradiation.

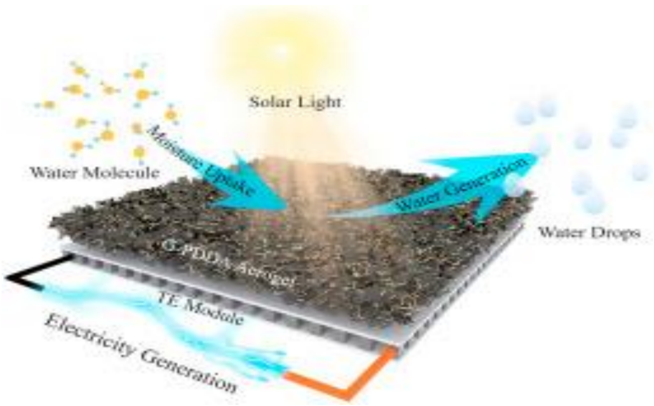

Fig 8 extract water from the atmosphere using a hygroscopic (G-PDDA) aero-gel

Shobhit Srivastava *et al* ., performed in order to generate water from atmospheric air by using different composite materials under atmospheric condition (fig 9) . In this analysis, three composite materials named LiCl/sand , $CaCl_2$/sand and LiBr/sand have been used as salt with 37% concentration and sand as a host material. The absorption process has been carried out at night in the open atmosphere whereas regeneration process took place during the day time by using newly designed 1.54 m^2 Scheffler reflector. The maximum water quantity generate from LiCl/sand is 90 ml/day, from $CaCl_2$/Sand it is 115 ml/day and from LiBr/Sand it is 73 ml/day in 330 min, 270 min and 270 min respectively through investigation.

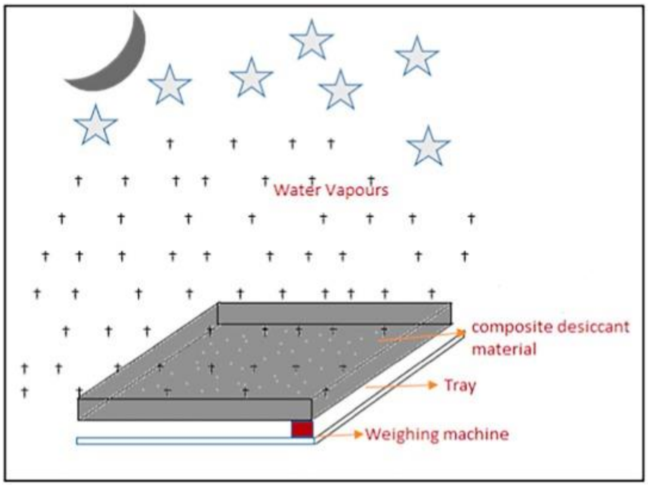

Fig 9 Generate water from atmospheric air by using different composite materials

Ahmed m mamed *et al* ., investigation on the application of solar energy to heat a sandy bed impregnated with calcium chloride for recovery of water from atmospheric air (fig 10). An experimental unit has been designed and installed for this purpose in climatic conditions of Taif area, Saudi Arabia. The sandy layer impregnated with desiccant is subjected to ambient atmosphere to absorb water vapour in the night. During the sunshine period, the layer is covered with glass layer where desiccant is regenerated and water vapour is condensed on the glass surface. Experimental measurements show that about 1.0 liter per m2 of pure water can be regenerated from the desiccant bed at the climatic conditions of Taif. Liquid desiccant with initial concentration of 30% can be regenerated to a final concentration of about 44%. This method for extracting water from atmospheric air is more suitable for Al-Hada region especially in the fall and winter.

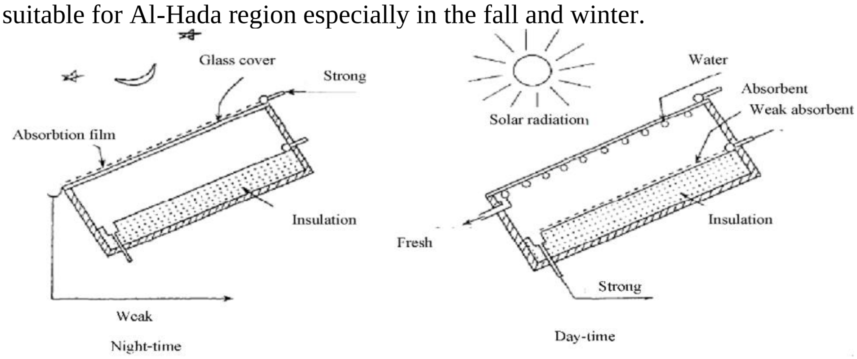

Fig 10 Solar Energy for Recovery of Water from Atmospheric Air

C. Dhandapani *et al* ., performed an Atmospheric Water Generator on Motor Vehicle device constantly provides drinkable water from atmospheric air (fig 11). There are mainly two methods1) Cooling condensation method : a compressor circulates the refrigerant through a condenser and then an evaporator coil which cools the air surrounding it. This lowers the air temperature to its dew point, causing water to condense. 2) Desiccant method, desiccants absorb the water molecules in the air. Desiccants may absorb atmospheric moisture by several methods: by physical absorption, forming chemical bonds or adsorption. Desiccants are Calcium chloride, Lithium chloride, Water gel crystals. Desiccation Technologies are superior over cooling condensation by water produced is clean of air contaminates and micro organisms , Solar heat can be used. Installed in a motor vehicle, the device constantly provides hot and cold drinkable water from atmospheric air and produce an unlimited supply of water without environmental pollution for the current water scarcity problem The device can be especially helpful for travellers and truck drivers who need water on long roads.

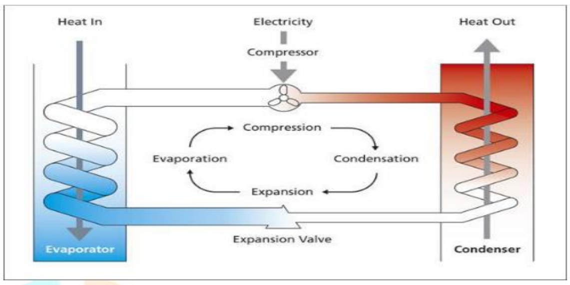

Fig 11 Modified AWGMV System

Eole Water is a French company specialized in the design and manufacturing of drinking water production systems (fig 12). The WMS 1000 is a unique technology able to supply fresh drinking water with no external power source and in due respect of the environment. Wind is the only power needed to operate the turbines. First it supplies the power needed to transform the humidity in the air into liquid water. Then, this energy is used to route the water to a storage tank.

Turbine operation – (Power production - Ambient air intake - Humid air condensation - Water production - Water filtration - Available fresh drinking water) With an electrical output of 30 kW, the WMS 1000 can produce up to 1000 l of drinking water per day and requires no additional external electrical input.

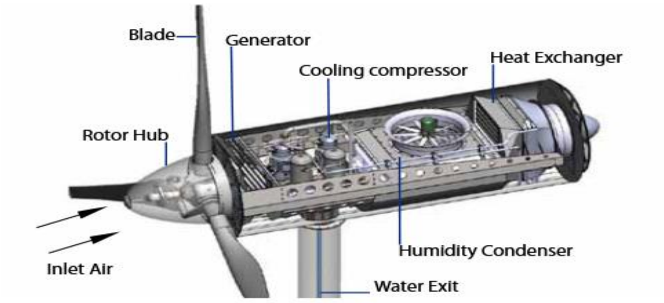

Fig 12 Eole Water From Wind To Water

Alina LaPotin *et al* ., Dual-Stage Atmospheric Water Harvesting Device for Scalable Solar-Driven Water Production (fig 13) reported that a dual-stage AWH device using commercial zeolite increased the productivity, and the latent heat of condensation was recycled from the top stage to assist in desorption of the bottom stage. The dual-stage framework can be used with high-performance adsorbent materials and in different AWH systems to improve thermal efficiency. This dual-stage device configuration is a promising design approach to achieve high performance, scalable, and low-cost solar-thermal AWH. The dual-stage device with daily water harvesting productivity of 0.77 L/m^2/day

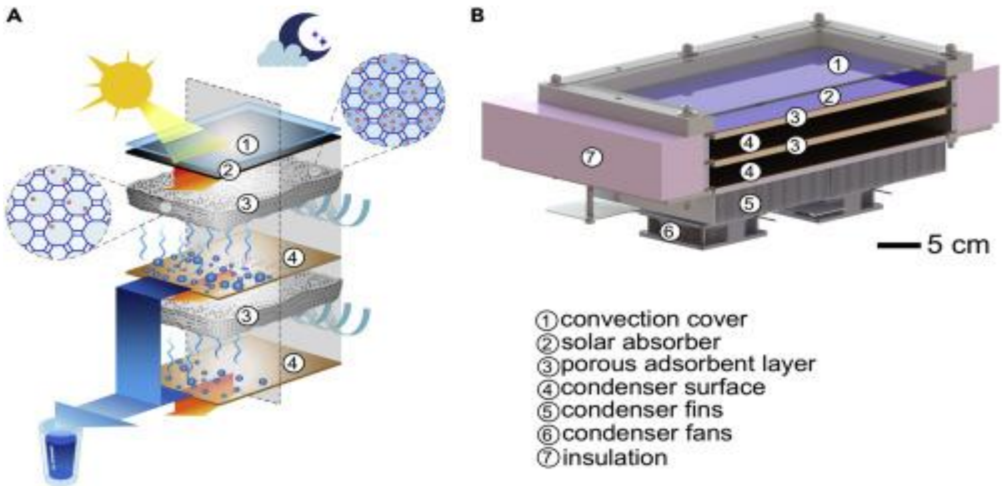

Fig 13 Dual-Stage Atmospheric Water Harvesting Device

5.DISCUSSIONS AND CONCLUSIONS:

About 4 billion people worldwide experience water scarcity. Water scarcity limits access to safe water for drinking and for practising basic hygiene at home, in schools and in health-care facilities. When water is scarce, sewage systems can fail and the threat of contracting diseases like cholera surges. Scarce water also becomes more expensive. Therefore extracting water from atmospheric air has received considerable attention from researchers world-wide. This review has described various technologies and we expect more to appear in future. Atmospheric water vapour is a world-wide resource and is available even in the driest place like desert, gulf countries etc.

Some hygroscopic materials can collect more water cheap materials can be fabricated from sawdust , silica gel, calcium chloride, recently developed modern metal organic framework (MOF) materials are able to operate with relative humidity as low as 20%, but will be more expensive. The maximum amount of water collected is 2.8 liters of water out of the air per day by metal organic framework. This research work will support further research on the extraction of water from atmospheric air

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