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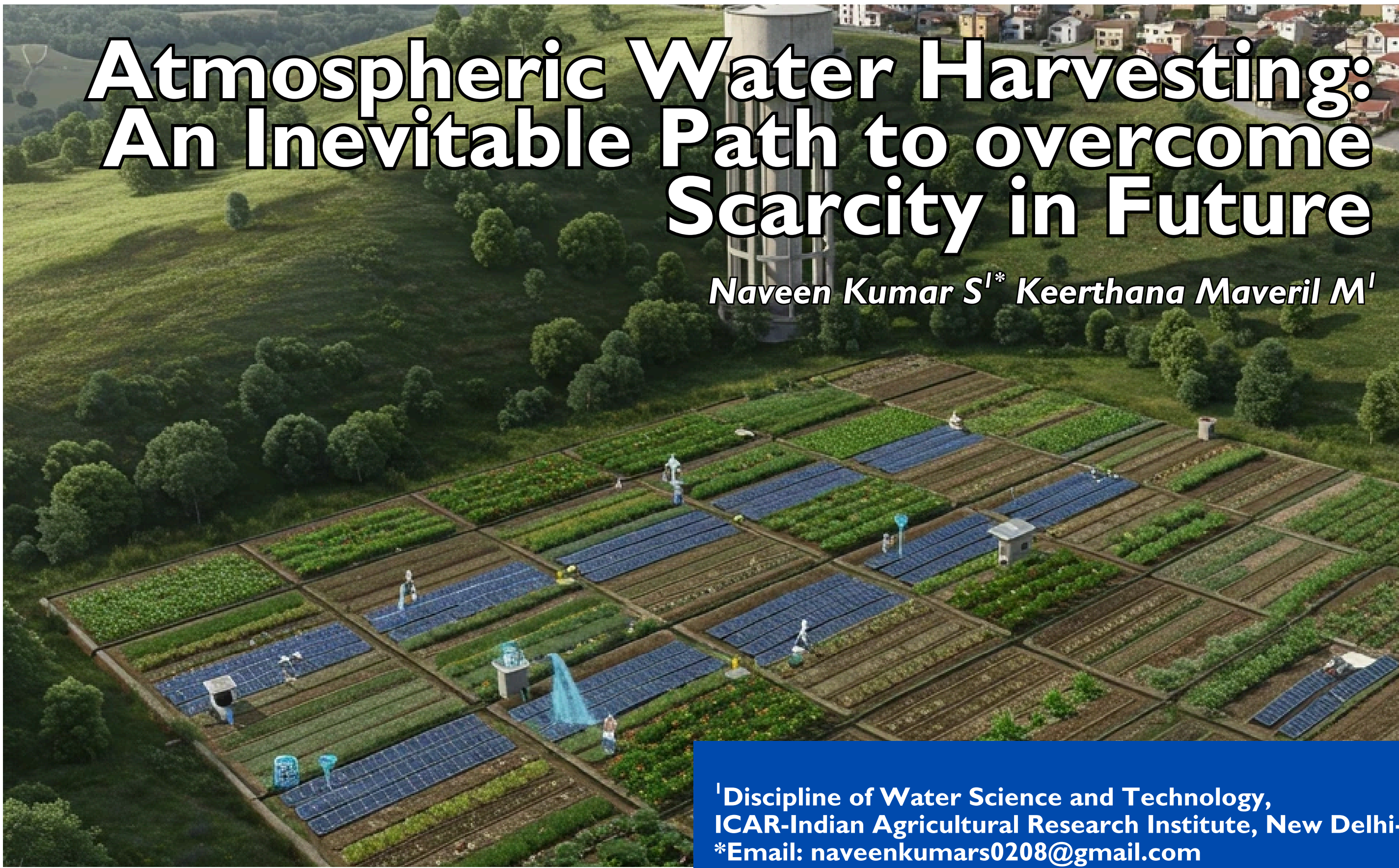

Atmospheric Water Harvesting: An Inevitable Path to overcome Scarcity in Future

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Abstract

Water scarcity is one of the inevitable global challenges recognized by the United Nations, and the level of water stress is anticipated to intensify. Atmospheric water harvesting is extracting water from the atmosphere, typically from humidity in the air, to provide a sustainable source of fresh water. The three main techniques are active cooling, passive cooling and desiccation technology. These technologies offer permissible solutions to the lack of drinking water in water scarcity areas. This article briefly overviews the evolution, principles, types and problems of atmospheric water harvesting.

Keywords: Water, technologies, atmosphere, harvesting.

Keywords: Kalpavriksha, nematodes, quarantine, management

Introduction

water stress is anticipated to increase in the upcoming years (Du Plessis et al., 2019). Both developed and developing countries are facing the challenge of freshwater shortages. Approximately 2.2 billion people lack access to water, while 4.2 billion do not have clean water sources or adequate sanitation facilities (Shingne et al., 2022). According to the United States Bureau of Reclamation, only about 3% of Earth's water is freshwater. Of this, 2.5% is inaccessible, trapped in glaciers, ice caps, the atmosphere, soil, or deep underground. The remaining 0.5% is the accessible freshwater available (Kunde et al., 2021). Approximately 13,000 km^3 of freshwater is found in the atmosphere, with 98% in vapour and 2% in the condensed phase. This amount is nearly equivalent to all the freshwater available on the Earth's surface or underground, excluding glaciers and ice caps (Gido et al., 2016). It offers safe drinking water at a small community level without harming the environment (Wahlgren et al., 2001).

Need for atmospheric water harvesting

Atmospheric water harvesting systems are a cost-effective, energy-efficient method for water collection compared to traditional water supply infrastructures. It is safer, chemically stable and environmentally

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friendly than other water sources. It can give life support for people to tolerate water scarcity in dry and polluted areas (Wang et al., 2018).

Fig. 1. Need for atmospheric water harvesting

Progress of major developments in fog water collection technology

In 1900, scientists at the University of California, Berkeley, conducted a study to measure fog water in Table Mountain. It leads to the foundation for developing a new fog water collection system type. Then, after 1969, the initial fog collection system was established in South Africa, using fog plastic screens. After the next two decades, research and experimentation continued and finally in 1987, 100 large Raschelmesh type fog collectors were installed to supply water in Germany. By 1995, many countries adopted this technology after successfully installing fog collectors in Chile. The timeline concludes in 2018 with the development of various designs of fog collectors, including 3D plastic mesh net structures

Principles of atmospheric water harvesting

The basic principle of atmospheric water harvesting was Condensation. The Namib Desert beetle has a unique surface texture with alternating hydrophobic (water-repellent) and hydrophilic (water-attracting) regions. Water droplets condensed on the hydrophilic sections and then moved down the waxy, hydrophobic grooves to the beetle mouth parts for drinking. This confusion has now been resolved, and researchers use this naturally found principle to develop fog collection techniques. Condensation is when a gas (usually water vapour) changes into a liquid. This occurs when the water vapour is cooled to its dew point, at which the air becomes saturated and cannot hold all of the water vapour as a gas. As a result, the excess vapour turns into liquid droplets. The process behind condensation involves the reduction in temperature, change of gaseous phase to liquid phase and latent heat of condensation.

Suitable weather conditions for Atmospheric Water Harvesting

Relative humidity: High relative humidity enhances the density of water droplets in fog.

Wind speed: Optimal wind speeds ranging from 2 to 5 m/s are required for effective fog collection, which can balance the sufficient airflow to transport water droplets to collection surfaces while avoiding excessive turbulence that disrupt the process.

Temperature: Temperature below 10℃ enhances condensation on collection surfaces, thereby

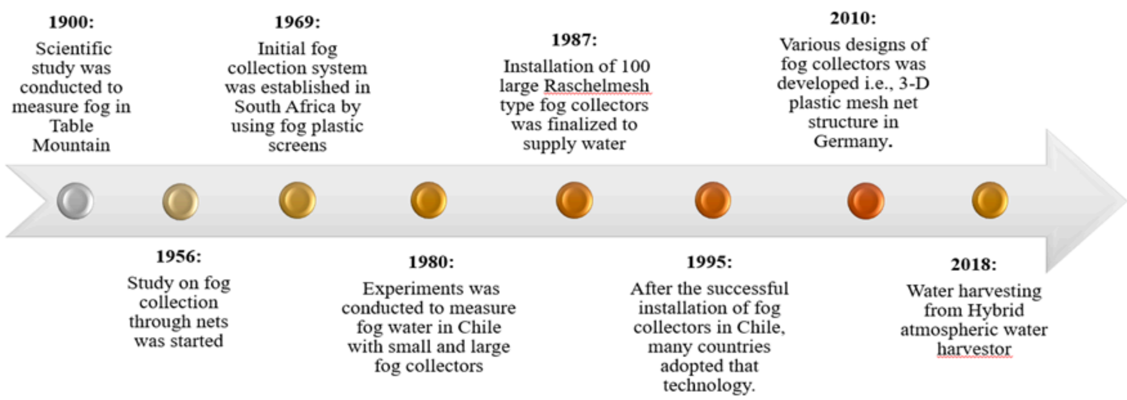

Fig. 2. Progress of major developments in water collection technology (Qadir et al., 2021)

improving water collection efficiency because lower temperatures increase the condensation rate on mesh surfaces used for atmospheric water collection.

Fog density Denser fog, influenced by factors like humidity and temperature, contains more water droplets, thus allowing for greater water collection

Atmospheric Water Harvesting Technologies

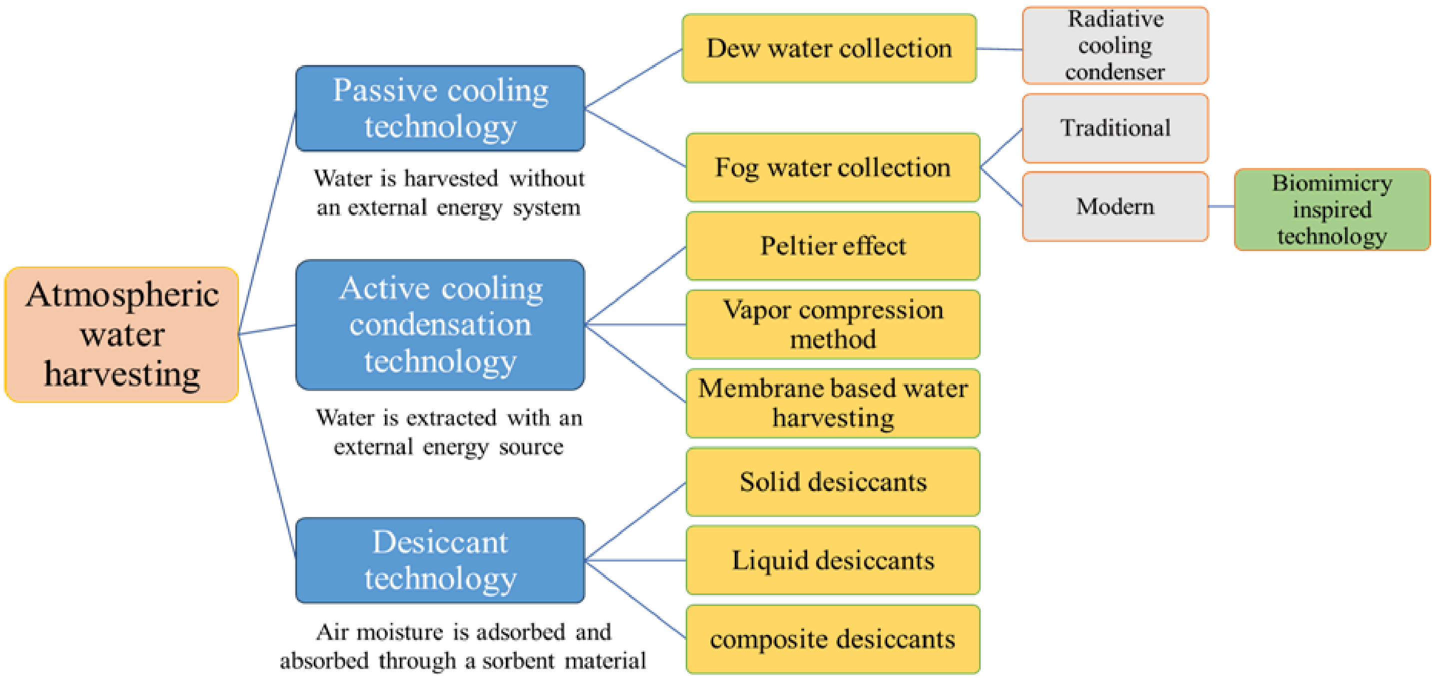

Fig. 3. Different technologies of atmospheric water harvesting (Bilal et al., 2022)

improving water collection efficiency because lower temperatures increase the condensation rate on mesh surfaces used for atmospheric water collection.

Passive cooling technology

Passive cooling technology collects atmospheric water without the use of external energy. It includes techniques like dew collection, i.e., radiative cooling condenser and fog water harvesting using traditional and modern methods inspired by biomimicry technology. Some of this technology includes Stimulus-trigger water collecting technology, which is bio-inspired by desert beetles, dip-coating strategy by spiders, etc.

Active cooling technology

It uses external energy sources to extract water from the atmosphere. In this technology, vapour compression, Peltier cooling, and membrane-assisted techniques are the modern methods that use active cooling technology to collect water from the atmosphere.

Desiccant technology

The sorbent materials can absorb moisture from the air, which can be collected by heating the absorbent to evaporate that water The water can then be placed in an enclosed chamber like glassware.

Problems behind atmospheric water harvesting

∅ Efficiency depends on humidity and temperature, reducing effectiveness in low humidity or cooler regions.

∅ Installation costs for advanced systems can be prohibitive.

∅ Regular maintenance is needed, increasing operational costs.

∅ Scaling up to meet large-scale demands remains challenging.

∅ Potential ecological disruptions need careful management.

∅ Ensuring potable water requires effective filtration and purification.

∅ Ongoing challenges include optimizing materials and enhancing collection efficiency.

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Conclusion

Atmospheric water harvesting is a promising and reliable source of life-saving potable water in arid regions and other water-scarce areas. It is also a supplementary resource for consumers and industries with limited water sources. It does not completely solve the world's water scarcity problems, but it can give a life path for thirsty people suffering from severe water scarcity. By improving this technology in the future, we will provide a new path and source of water for future generations.

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