Water Harvesting Using Fog Water and Rain Water Catcher

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Abstract—India got a high potential of fog water harvesting which has not yet utilized. In Hilly rural areas no firm water source is available, fog harvesting can be boon to such places. The system is designed to harness the water vapor present in fog and convert it into usable liquid water. The fog water collection system aims to address water scarcity challenges in regions where fog is a frequent occurrence. It utilizes specialized structures, such as fog collectors or fog nets, to capture the tiny water droplets suspended in the fog. These droplets condense on the surface of the collectors and gradually form larger water droplets that can be collected. The abstract emphasizes the significance of fog water collection as an alternative water source, particularly in arid and semi-arid regions with limited access to conventional water supplies. It highlights the system's potential to supplement local water resources and enhance water security, touch upon the environmental benefits of fog water collection, such as its sustainability and reduced reliance on groundwater or surface water. It may also mention the system's suitability for remote and rural areas where infrastructure for conventional water supply may be lacking. Furthermore, It may mention the challenges associated with fog water collection, including variations in fog density, climatic conditions, and the need for appropriate maintenance and monitoring to ensure optimal performance. In summary, it provides a succinct overview of a fog water collection system, outlining its purpose, benefits, and potential challenges. It serves as a concise introduction to the topic and can provide a foundation for further exploration and research in this field.

Keywords (*Fog, sustainable method, water quality.*)

I. INTRODUCTION

Asian subcontinent is much liable for formation of fog due to less temperature and adequate humidity. According to estimates, "fog capturing" via net screens can efficiently

capture 12.5 billion liters in India. Although rainwater harvesting is the most used method of water conservation, a new system called as "fog water harvesting" has been developed. Given the ease of the required technology and the passive functioning of the collecting and distribution system, fog is a desirable source of freshwater. The fog water harvesting works on simple principle, cost effective and epitomizes the new age "green technology and sustainable development" for water resources. It is based on the principle that whenever mist or fog i.e., a mass of water vapor condensed into small water droplets at, or just above, the Earth's surface which is driven by wind touches a fog net (a metallic or net surface) it condenses to form dew or droplets of precious water. In other words, carried by the wind, liquid water droplets impact the mesh fibers, clusters, and flow down into a gutter and drain through tubes into collection tanks or pools under the influence of gravity. Mountainous regions or valleys are most suitable sites fog water harvesting where dense fog collects which can be turn inpure drinking water.

Though, fog is usually considered to be a harmful, fog water represents the only source of water for many animals and plants in arid and semi-arid regions and has been passively collected by people living in these areas since ancient times. Fog water collection systems do not need external energy sources, are inexpensive, simple to build and operate, and are environmentally friendly.

The Sustainable Development Goal (SDG) 6, which calls for access to adequate water and sanitation for all by the year 2030, supports initiatives in water- scarce nations and regions to go beyond traditional resources and tap unconventional water supplies to close the water demand-supply gap. Of all the unconventional water resources, the ability to collect water from the air, such as through fog

harvesting, is the one that is most neglected. The passive, low- maintenance, and sustainable alternative of collecting fog water to produce clean drinking water may benefit communities that commonly suffer fog episodes. Because of their straightforward designs, fog collection systems are typicallyinexpensive and simple to use.

Peninsular Plateau of India contains mountain ranges and has an adequate amount of rainfall but as due to insufficient amount of water infrastructure, topographic characteristics, rainfall availability water cannot be stored and used throughout the years in rural area. Thus, in rural areas fog water harvesting can be beneficial with limited water requirement and lesser population. Every winter, the Delhi capital city and the locations like Gwalior, Kanpur, and Allahabad, there is a noticeable and lingering fog. The largest area of India impacted by fog in the winter is the entire Indo-Gangetic plain, which is location south of the Himalayas. This method is perfect for water augmentation during the dry season in a few north-eastern regions, including Manipur, Arunachal Pradesh, Mizoram, Assam, and occurrence, particularly in Coorg, Kodai, the Nilgiri highlands, Wagamon and Munnar, Attappadi, and Pathanamthitta. This shows the capacity of fog collection in India though fog harvesting technologies are still in their beginning stages and has not been adopted on large scale or in communities due to absence of awareness and encouragement. In the most isolated areas of India, people might be empowered to get water directly from the atmosphere with a little encouragement and guidance from local authorities. Such creative and affordable solutions are likely to be successful soon given the country's water shortage.

II. NEED OF PROJECT

To harness the atmospheric water fog water collection is a most suitable method. Mountainous & valley region with Foggy condition holds potential as fog collection sites. Small communities in such area can have prominent sustainable source of water as Fog water, which can be used for daily needs and for acute water farming (Dryland farming). India got only 4 percent of its water resources, making it among the most water-stressed in the world thus with proper guidance, awareness and encouragement communities in India can have fog water as a water resource.

III. PROBLEM STATEMENT

Farming in arid mountainous region has been depreciating due lack of source of water. Not only farming but drinking water is also major concern in same regions. Fog harvesting can provide alternative source of freshwater through a technique used to capture water from wind-driven fog.

IV.STUDY AREA

Respected project's research area is in Nashik.
Latitude and Longitude: 19.9975° N, 73.7898° E
Rainfall: About 1134 mm | 44.6 inch of precipitation falls annually.
Fog collection in Nashik, India, has gained attention as a potential solution to address water scarcity in the region. Nashik, located in the state of Maharashtra, experiences fog events during the winter months, making it suitable for fog-water harvesting. While specific literature on fog collection in Nashik is limited, the general principles and experiences from fog collection in similar regions can provide insights.
Fog Occurrence: Nashik experiences foggy conditions during the winter season, typically from November to February.The frequency, duration, and intensity of fog events in Nashik may vary from year to year and depend on local climatic factors.
Water Collection Systems: Various fog collection systems have been employed worldwide and can potentially be adapted for use in Nashik. These systems typically involve the use of fog nets, vertical mesh collectors, or other specialized structures strategically placed in fog-prone areas to capture water droplets. The design and installation of fog collection systems should consider local meteorological conditions and terrain characteristics.
Water Yield and Quality: Studies conducted in similar fog-prone regions indicate that fog-water collection can provide a significant additional water source. Water yield depends on factors such as fog density, wind speed, and the efficiency of the fog collection system. Fog water is generally clean and suitable for various non-potable uses, although local environmental factors and contamination sources should be considered.

V.METHODOLOGY

The assessment of fog water collection technology was carried out in region of Western Ghats (Nasik), Maharashtra. The focus of present article was to implementation of pilot project to;

a) Identify the suitability of fog water harvesting system in different areas
b) To validate system using experimental analyzing
c) To checked the water quality of collected water.

SITE SELECTION

A suitable site at KBTCOE of Nasik region was selected by taking into account various factors mentioned below. The first step is to analyze whether the preliminary conditions for the presence of fog are present, i.e., the macro scale factors and the type or types of fog that may be found in the area. The use of a map and the relationship of factors such as the location of the site in the continent (coastal or inland), anticyclones, ocean currents, mountains and wind directions may be of great help. The study of the climate of the area may

also give the necessary information, especially In Koppen's classification that has for the arid and semiarid regions. At low elevations, many days will be cloudy but in the mountains it may be foggy. The presence of mountains is vital, for as was stated earlier, advection and orographic fog (the kinds of great interest) are found at high elevations. If there is no surface to intercept the cloud, the latter will continue to move inland and dissipate from the heat generated by the dry land. Altitude is another important feature, as a low elevation land surface will not intercept the cloud, since the latter will simply pass over it. Humidity of the region was monitored for a month to determine the potential of fog water generation from selected site

MODEL DEVELOPMENT AND FOGWATER COLLECTION

In the open area of the selected site at Nasik, a large fog collector were built and operated simultaneously to capture the fog (Figure 1). A collector consisted of a flat; rectangular screen supported by a rectangular PVC frame and arranged perpendicular to the direction of the fog- bearing wind. The base of the frame of the fog collectors was 1.5 m above the ground. Green plastic shade mesh was used as a medium material to entrap the wind driven fog. A lateral drain was provided below net connected to horizontal pipe so as to collect water. The tank of 15L was provided at base to store water collected which was connected with a tube lateral drain. The selection of these materials was based upon various factors such as availability in the local market, cost and durability. More details about the selection and testing of greenhouse shade nets for the collection of fog can be found in Shanyengana et al. (2003). Its dimensions were 2 × 1.4 meter and 18 GA (0.0403 inch) thick. The green plastic shade mesh was 70% shade coefficient polypropylene mesh (i.e., with a collecting surface area of 2.8 m2) and used in a single layer. The design of the fog collector was the same and based on that used at El Tofo, Chile (Cereceda and Schemenauer 1991, Schemenauer and Cereceda 1994a) and Dhofar, Oman (Alesh 1998, Schemenauer and Cereceda 1994a, Abdul-Wahab et al. 2007a, 2007b), but modified for local conditions. It should be noted that both fog and rainwater were collected by the collectors. The experiments were designed and implemented between 12th of December to 15th of January. The daily measurement of the water collected was noted. The collected water was used for experimental work to carry out water drinking tests to determine feasibility of water for drinking purpose.

Figure 1. *Picture showing the actual fog collector used in the field study*

VI. RESULT AND DISCUSSION

The daily totals of fog and rainwater collected by the fog collector during December and January are summarized in Table 2. The fog collector had different water collection over different climatic condition. The total fog collection of the green plastic shade mesh fog collector was, or an average of 0.554 L/d. The total daily amount of fog collected during mid-December was generally more than that collected in January. The total amount of fog collected by the green plastic shade mesh was only 19.1 L/m2. Details on how to properly correct the total water collected for the rainfall component can be found in Schemenauer and Cereceda (1994). The screen would collect both fog and rain water; but due to absence of rain no rain water was collected.

Table 1*: Humidity data of selected site*

Date	Minimum Temp. (^{0}C)	Humidity (%)
25-11-23	23	59
26-11-23	20	66
27-11-23	19.44	69
28-11-23	19.88	65
29-11-23	19	68
30-11-23	18.23	74

01-12-23	21	61
02-12-23	18.13	76
03-12-23	23.88	55
04-12-23	18	73
05-12-23	18.82	78
06-12-23	17.89	79
07-12-23	17	81
08-12-23	16.78	83
09-12-23	17.22	79
10-12-23	16	86

Fog water collection data in Nashik can be obtained through monitoring and measurements conducted in the region. Understanding following factors can help in assessing the potential for fog water collection in Nashik.

Fog Occurrence: Fog occurrence refers to the frequency and duration of fog events in a particular area, such as Nashik. This information can be obtained from historical weather records and meteorological data specific to the region.

Fog Density: Fog density is a measure of the concentration of water droplets in the fog. It influences the water yield potential of fog water collection systems. Higher fog density generally results in increased water collection rates.

Wind Speed: Wind speed plays a crucial role in fog water collection. It affects the movement of fog droplets towards collection surfaces. Higher wind speeds can improve the droplet capture efficiency by reducing droplet loss due to advection or dispersion.

Collection Efficiency: Collection efficiency refers to the percentage of fog droplets that are successfully captured by the fog collection system. It depends on various factors such as the design of the collection structure, surface properties, and the size distribution of fog droplets. Collection efficiency can be influenced by parameters such as fog density, wind speed, and the specific characteristics of the fog collection system employed in Nashik.

To obtain fog water collection data for Nashik, it would be necessary to conduct field measurements or refer to studies specifically carried out in the region. These measurements typically involve the installation of fog collection systems and the collection of water samples to determine the yield and quality of captured fog water. This collected data is shown in following table;

***Table 2** : Fog Water Collection Data*

Date	Total fog and rain water collected(L)	Water per m^2Of Collecting Net (L)
12/12/2022	0.92	0.328
13/12/2022	1.08	0.385
14/12/2022	0.98	0.35
15/12/2022	0.87	0.310
16/12/2022	0.73	0.260
17/12/2022	0.64	0.228
18/12/2022	0.51	0.18
19/12/2022	0.49	0.175
20/12/2022	0.45	0.160
21/12/2022	0.48	0.171
22/12/2022	0.42	0.15
23/12/2022	0.41	0.14
24/12/2022	0.49	0.175
25/12/2022	0.55	0.196
26/12/2022	0.56	0.2
27/12/2022	0.505	0.180
28/12/2022	0.48	0.171
29/12/2022	0.34	0.121
30/12/2022	0.37	0.132
31/12/2022	0.45	0.160
01/01/2023	0.49	0.175
02/01/2023	0.35	0.125
03/01/2023	0.38	0.135
04/01/2023	0.43	0.153
05/01/2023	0.49	0.175
06/01/2023	0.62	0.221
07/01/2023	0.77	0.275
08/01/2023	0.65	0.23
09/01/2023	0.53	0.189
10/01/2023	0.4	0.142
11/01/2023	0.4	0.142
12/01/2023	0.445	0.158

13/01/2023	0.53	0.189
14/01/2023	0.48	0.171
15/01/2023	0.36	0.128

The tests were conducted on collected fog water to check the properties of water which would decides the uses of water. As various tests are performed on fog water following results are obtained:

***Table 3**: Test Result*

Sr. No.	Name of Test	Result	Desirable Range
1	pH	6.81	6.5-8.5
2	Turbidity	3 NTU	5 NTU
3	Alkalinity	52 mg/l as $CaCO_3$	600 mg/l as $CaCO_3$
4	Hardness	210mg/l as $CaCO_3$	600 mg/l as $CaCO_3$
5	Dissolved Oxygen(DO)	Present	-

1. pH

As per BIS the desirable range of pH is between 6.5 to 8.5.

From the test conducted of fog water the pH value is 6.81. The obtained result from the test is in desirable limit.

2. Turbidity

As per BIS the maximum permissible limit of Turbidity is 5 NTU.

From the test conducted of fog water the Turbidity value is 3 NTU. The obtained result from the test is in maximum permissible limit.

3. Alkalinity

As per BIS the maximum permissible limit of Alkalinity is 600 mg/l as $CaCO_3$.

From the test conducted of fog water the Alkalinity value is 52 mg/l as $CaCO_3$. The obtained result from the test is in maximum permissible limit.

4. Hardness

As per BIS the maximum permissible limit of Hardness is 600 mg/l as $CaCO_3$.

From the test conducted of fog water the Hardness value is 210 mg/l as $CaCO_3$. The obtained result from the test is in maximum permissible limit.

5. Dissolved Oxygen (DO)

As per obtained results, Dissolved Oxygen (DO) is present in the sample of fog water.

VII. ADVANTAGES

- Supplemental Water Source: Fog water harvesting involves collecting water droplets from fog, which can be a valuable supplementary source of water in regions with low rainfall. Nashik experiences foggy weather during certain seasons, making fog water harvesting a viable option to augment the water supply.
- Drought Mitigation: Nashik faces periodic drought conditions due to its arid climate. Rainwater harvesting can help mitigate the impact of droughts by capturing and storing rainwater during the monsoon season. This stored water can be utilized during dry periods, reducing the dependence on scarce water resources.
- Sustainability and Conservation: Both fog water and rainwater harvesting systems promote sustainable water management by reducing reliance on traditional water sources such as groundwater or rivers. By collecting and using locally available water resources, these systems conserve water and reduce the strain on existing supplies.
- Cost-Effective: Implementing fog water and rainwater harvesting systems can be cost-effective in the long run. While there may be initial setup costs, the maintenance and operational expenses are generally lower compared to alternative water supply options. Additionally, utilizing fog and rainwater can help reduce water bills for households and businesses.
- Environmental Benefits: Harvesting fog water and rainwater reduces the burden on natural ecosystems and water bodies. It minimizes the need for extensive water extraction from rivers or drilling borewells, thereby preserving local biodiversity and maintaining ecological balance.
- Increased Resilience: By diversifying the water sources, Nashik can enhance its resilience to water scarcity and variability caused by climate change. These systems provide an additional buffer during times of water stress and can support water-intensive activities like agriculture, industries, and domestic use.
- Community Engagement: Implementing fog water and rainwater harvesting systems can involve local communities in water conservation efforts. It fosters awareness and participation, encouraging individuals and organizations to take an active role in sustainable water management practices.

VIII. CONCLUSION

The present study was carried out during the winter season in order to determine the effectiveness of fog water collection system. Green plastic shade mesh collectors were used. An analysis of fog and rain water collection data was carried out. The findings revealed the existence of significant amounts of fog and rain water collected by green plastic shade mesh collector. The water collected could be used as a drinking water after primary treatments or to supplement or replace the groundwater.

It can be seemed that the green shade plastic mesh collected less water compared to its efficiency. The underlying cause of this was related to the fact that site present on low ground without having mountainous terrain. It was observed that the humidity of region was low for the condensation of water and fog formation. From the Satellite imagery the site selected doesn't experience fog throughout the monsoon and winter which resulted less fog water collection.

Therefore, this work can be useful contribution to the field of water resource augmentation.

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