

The implementation of fog water collection systems in Northeast of Iran

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Abstract

Asia may very well be one of the most beautiful places in the world, but after you get underneath all the beauty there is a sense of pain. Asia is home to many thirsty and starving men, women and children. A shocking 55.3 percent of the population of Southeast Asia doesn't even have the ability to drink safe water. Since 2004, a research has been carried out on the collection of water from fog in Khorassan - northeast of Iran. The study is the evaluation of the possibility of obtaining water for different uses of the local population (domestic, agricultural, cattle rising and forestry), by means of fog collectors. The instruments used during this study were fog collectors of different sizes and shapes, meteorological instruments and visual measurements of the fog. The experiments indicated fog water collection holds considerable potential as an alternative water source in the mountainous area. It is feasible to obtain an average water production of $0.53 \text{ l m}^{-2} \text{ day}^{-1}$. The maximum amount of water collected in a day was $3.3 \text{ l m}^{-2} \text{ day}^{-1}$. The numbers and size of the modules chosen will depend on local topography and the quality of the materials used in the panels. According to the research of that multiple nylon mesh system can absorb and collect more water than a comparable plain system, we may build a complex structures machine that can collect more water. Alternatively, the collectors may be more complex structures, made up of a series of such collection panels joined together. The complete system can be easily built or assembled on site. Installation and connection of panels is quick and simple.

Keywords: Fog, Fog Collector, Water

Introduction

Although water is Nature's most abundant substance, only 3% of the world's water is fresh. Less than 1% of the fresh water is accessible, in rivers, lakes, and underground reservoirs; the rest is suspended in the atmosphere or trapped in glaciers and the polar

ice caps (1). There is an urgent need to develop technological solutions that can provide enough water to serve rural or suburban communities, which are normally isolated from conventional supply systems. Such solutions should permit more equitable access of people, and the natural resources available to them, to productive activity and economic development. Professor Jana Olivier of the University of South Africa's department of anthropology, Archaeology, Geography and environmental studies, explains that the idea of harnessing fog as a source of drinking water has been studied for decades. The first experiments were conducted in 1901, on Table Mountain. But it was only in 1987, in the arid coastal desert of northern Chile, that it was implemented on a large scale (9).

In some regions because of special meteorological and topographical characteristics fog occurs regularly. The leaves of trees collect the droplets in fog. Recently technology helps man to get more water by artificial fog collectors.

The projects comprised the following aspects: (a) designing, erecting and operating of a different kind of fog collectors; (b) monitoring water quality and investigating the relationships between various meteorological variables and cloud water yield. This article gives an overview of the selection of the experimental sites, the design of the fog collectors system, water yields obtained.

Some main factors should be taken into account when determining a suitable site for fog collectors, namely, (a) the potential of collecting large volumes of water, (b) accessibility, (c) the proximity of a water-poor community and (d) security(2). The first factor is discussed in this paper. Since the clouds are carried to the site by the wind, and the fog is then moved through the collectors by the wind, the interaction of the large- and small- scale topographical features with the wind will enlarge part determine the success of the site chosen(3). A number of the most important geographical factors will be briefly reviewed here.

- Persistent winds from one direction are ideal for fog collection.

- A field of dunes or a mountain range that rises high enough is necessary to intercept clouds of fog that are advanced in to the region.
- The region of the stratocumulus cloud, which normally has the highest liquid content, is between 400 m to the direction of the wind bringing cloud and fog from the ocean.
- One should try and work as close to the coast as possible, ideally within 5 km but possibilities exist up to at least 25 km inland.
- It is very important that there be no major obstacle to the wind within a few kilometers of the site.
- An upwind ridgeline that there is no major obstacle to the wind within a few kilometers of the site.
- The presence of an inland depression or basin that will heat up during the day will cause a local low-pressure area. This will enhance the sea breeze and increase the wind speed with which marine cloud decks flow over the terrain(4).

Fog is created as a result of an area's topography and proximity to bodies' water, most prevalent in coastal regions. Some regions that experience of fog are also some of the most arid places on the earth receiving little or no rainfall. It is here that this

technology is most appropriate. The fog collectors require fog that has a high moisture content, that being convection fog (6). Some kind of cloud is composed of droplets that are so small that they move at the caprice of the trade winds and have not enough weight to fall to the ground in the form of precipitation, although they are deposited on the leaves of the trees when they flow over the relief of the Islands. The environmental conditions of these foggy places are characterized by very low visibility and elevated atmospheric humidity. The technology used in order to extract the water is low in price and has been tested with success in various countries (Schemeneauer and Cereceda): in Chile (Cereceda et al., 1992); in South Africa (Olivier and Rautenbach); in Nepal (Mac Quarrie et al., 2001) and in Dominican Republic (Schemeneauer et al., 2001) (11). The average wind velocity in the fog episodes is 2.5 m s⁻¹ which, despite the fact that it is within the limits considered optimal by Schemeneauer and Joe (1989) for water collection, is a low speed for efficient collection of water (11). The delivery of the water usually requires no energy since the collectors are often located in the hills above settlements. Evaluation projects have taken place in Namibia, the Canary Islands, South Africa, the Sultanate of Oman, Mexico and Nepal. Perhaps the biggest and most successful project took place in the arid but fog-shrouded fishing village Chungogo, on the central coast of Chile. Fog collection will not be answer to the world's water shortages, Schemeneauer says, but can function as a highly efficient complement to other water supplies (10).

The potential for extracting water from fog is a function of the amount of water it contains, how often it occurs, and wind speed. The fog water content depends upon its altitude. Its frequency of occurrence depends on regional atmospheric circulation, the temperature of the ocean water and the stability and intensity of the thermal inversion processes (1). If the climatic phenomenon that produces the fog is stable, fog will form regularly; however, its behavior may vary from one area to another and specific seasonal variations may occur. On South America's Southwest coast, especially in Chile, the fog-producing conditions are constant throughout the year, although more intense during the spring and summer months and less during fall and winter (2). One of the largest projects has provided, since March 1992, an average of 11000 liters of water per day to a village of 330 people in arid coast desert of North Chile (Schemeneauer R. & Cereceda P., 1994). Water yield depends upon a high fog occurrence, the persistence of fog episodes and the presence of fog bearing winds. Sites with higher elevations would obviously receive more water from fog due to the increase in wind speed and moisture content of fog with height. In the mountainous areas, elevation was the most important contributing factor to water yield. A power function was derived to successfully predict yields from elevation values (Olivier and Van Heerden, 1999). Ideally, sites should also be more than 1000m above sea level. Sites in many parts of South Africa have elevations of more than 2000m, and according to previous experiments, these sites could yield more than four times the volumes recorded at Tshanowa in the Soutpansberg (9).

Material and Methods

For fog collection to be effective, the site must be an area where fog accrue frequently

throughout the year, and lasts for a few hours at a time. The water content of the fog should be high, and the fog must be accompanied by wind to ensure that a large enough volume of moist air is blown through the collecting screens (9). This information is based on the data obtained from the highest altitudes. From the data of the meteorological measurements, the period of time that was analyzed were only those during which water entered into the collectors without rain being measured. The period analyzes covers March 2004 to August 2005. Fortunately records from the water flow meter could be used to give more accurate results. Table 1 gives a summary of the daily water yields collected from the sites during the period March 2004 to August 2005. Unfortunately, no data were available for the period during which the heaviest rainfall occurred. The largest volumes were collected during March 2004 to August 2005. The area is located at about 55 km north of Mashhad . local conditions, such as altitude and relief; explain the differences in the amount of fog. The average collection rate during the total recorded period was just above $0.53 \text{ l m}^{-2} \text{ day}^{-1}$.

Table1 : Water obtained from fog in different collector in ($1 \text{ m}^{-2} \text{ day}^{-1}$)

Flat rectangular fog collector	simple cylinder fog collector	double cylinder fog collector
0.345	1.455	1.443
0.276	1.273	1.340
0.345	3.227	1.985
0.414	1.455	1.443
1.897	2.227	1.649
0.405	0.909	0.258
0.517	1.364	0.619
0.474	1.045	0.412
0.431	0.909	0.309
0.448	0.909	0.335
0.052	0.091	0.041
0.250	0.500	0.258
0.672	1.364	0.670
0.190	0.409	0.206
0.147	0.318	0.103
0.164	0.318	0.155
0.103	0.227	0.077
0.086	0.182	0.052
0.052	0.045	0.000
0.293	0.364	0.232
0.095	0.182	0.077
0.362	0.500	0.206
0.086	0.182	0.052
0.052	0.045	0.000

The sectors located at the highest altitudes in the north of Mashhad experienced the greatest average amount of fog water in winter and spring. The design of three collectors is the same and water can be collected by intercepting the fog as it is carried by the wind. Water droplets collide with the apparatus, which resembles a nylon strings, and become trapped on its fibers. The collection system constructed of simple, low-cost materials, available locally. The factors which determine the selection of sites for this research were topography, altitude and orientation, and the proximity of those sites to places where water is required. Three collectors made, namely, (a) flat rectangular fog collector, (b) the simple cylinder fog collector and (c) double cylinder fog collector.

(a) *Flat rectangular fog collector*: About 580 fine nylon strings (1 mm wide and .2 mm thick) are arranged to form a m high rectangular ‘fog catcher’. These strings supported by a post at either end and arranged perpendicular to the direction of the prevailing wind. The surface area of net was 1 square meter. As water collects on the net, droplets join to form larger drops that fall under gravity toward a trough or gutter located at the bottom of the panel. The fog collector is mounted approximately 90 cm off the ground (fig.4).

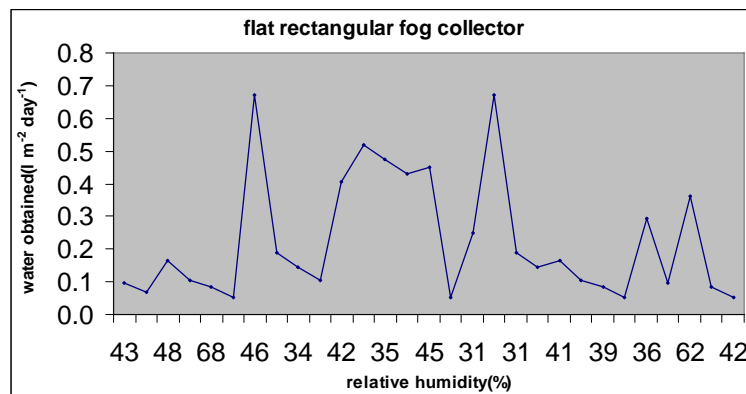


Figure 1 : Water obtained from flat rectangular fog collector.

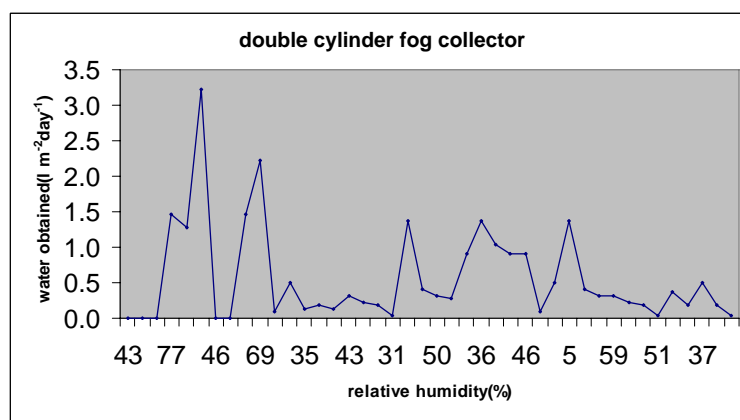


Figure 2 : Water obtained from double cylinder fog collector.

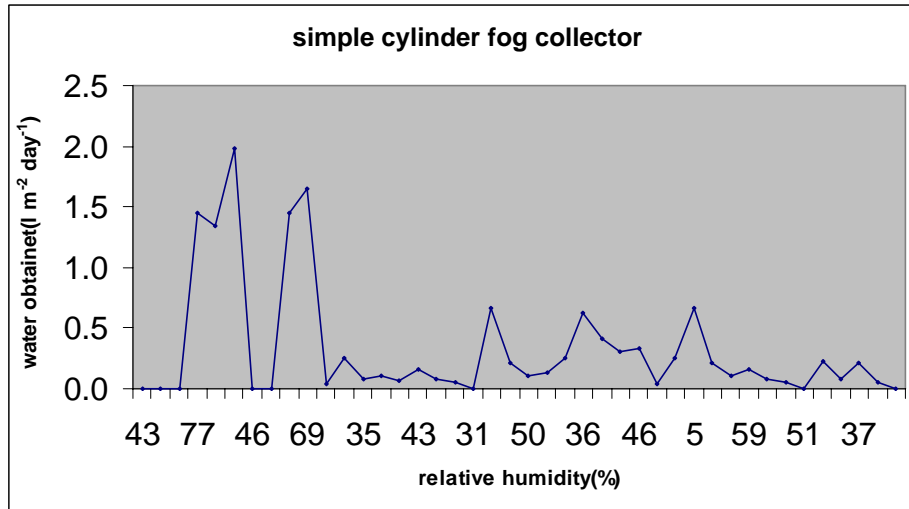


Figure 3 : Water obtained from simple cylinder fog collector.



Figure 4 : Flat rectangular fog collector

(b) *The simple cylinder fog collector:* This collector is a, 22cm diameter at top and 14 cm diameter at bottom by 38 cm high, strung with two concentric rows of Teflon monofilament. There is a rain shield approximately 30 cm diameter over the cylinder. The cylinder is mounted approximately 75m off the ground. The fog droplets collect on the filaments and drain through a funnel into a gallon (fig.5).



Figure 5 : Simple cylinder fog collector

(c) *The double cylinder fog collector:* This collector involves two cylinders inside each other, one cylinder 25 cm diameter by 43 cm height; another is a 5 cm diameter at top and 25 cm diameter at bottom by 73 cm height, strung with two concentric rows of Teflon monofilament. There is a rain shield approximately 30 cm diameter over the cylinder. The cylinder is mounted approximately 54 off the ground. The fog droplets collect on the filaments and drain through a funnel into a gallon (fig.6).



Figure 6 : Double cylinder fog collector

Finally, from the cable at the lower edge of the panel hangs a gutter or trough, anchored by galvanized wires. The trough catches the water that runs down the mesh net and carries it to a pipe connected to a mains or shortage tank.

Results & Discussion

A fog collection system can be easily built or assembled on site. Installation and connection of the collection panels is quick and simple. Assembly is not labor intensive and requires little skill. No energy is needed to operate the system or transport the water. Maintenance and repair requirements are generally minimal. It has the potential to create viable communities in inhospitable environments and to improve the quality of life for people in mountainous rural communities (7). The system is very ecologically sound as we are simply taking advantage of moisture that would otherwise be lost in to the atmosphere. It has virtually no negative impact on the ecosystem, is economically viable, and is eventually left in the hands of the local users to manage and maintain (6). Fog collectors can go anywhere, even on top of buildings. Wherever there is a relatively clear area free of trees (so there is more wind and cloud) is a good spot (6).

In conclusion, it appears that despite the poor quantity and quality of traditional sources of fresh water in Iran, there are possible solutions to alleviate the water scarcity. Fog is a viable source of water that can supplement traditional sources in rural settlements and perhaps urban water supply schemes. The water supply can be increased by adding extra collector panels, keeping in mind the capacity of the conduction system. Otherwise, the potential for collection is limited only by the availability of physical space for installing collectors. The water obtained by this system is important to the small populations where access to drinkable water is difficult and expensive, but nevertheless, its provision is crucial for their sustainability (10). The main purpose was to compare the amount of water collected in different collectors, and the study was carried out in four sectors whose characteristic, available information and methodology are the different. Higher amount of water were collected on the double cylinder fog collector (table.1), the highest water volumes do not always coincide with abundant rainfall. Days on which water was collected are referred to as wet days since the water could have been due to either rainfall or fog deposition. Fog days were those days where water was collected but no rainfall was recorded. The results indicate that in terms of both quality and magnitude of yield-cloud water harvesting could be used successfully to supplement water supplies in the fog prone regions of the arid country. However, care must be taken to select a suitable site and to ensure that the orientation of the collector is perpendicular to the direction of fog bearing winds. However, the measuring period involved is still too short for full conclusions.

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