GLOBAL WARMING AND THE THIRD WORLD

Fog collection

Previous article

Return to Tiempo index

Next article

Robert Schemenauer and Pilar Cereceda describe the unique process of collecting fog as a complementary source of water supply.

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Lakes and rivers, wells and the sea, these are the sources of water most people would list if asked. Initially, though, the water in all these reservoirs comes from precipitation. And even this isn't the total answer since there are also small contributions from dew and frost, and a larger hidden contribution from fog.

For centuries people have known that trees collect the tiny water droplets that make up fog. This covert water input, in the mountainous and coastal regions of our planet, was called occult precipitation in the last century and the terminology persists in some of the literature to this day.

The ever-growing need for fresh water in both developing and developed countries is indisputable and both increasing populations and the contamination of existing supplies will lead to constantly escalating demands. We must, therefore, begin to consider the use of non-traditional water supplies such as the collection of fog. As clouds move over hills and mountains, the hilltops and ridgelines are enveloped in fogs. Just as the leaves and needles of trees can collect some of the water in these fogs, large artificial collectors can produce a flow of potable water.

This simple technology has its roots in antiquity. "...But there went up a mist from the earth, and watered the whole face of the ground..." (Genesis, Chapter II, Verse 6). Is this a reference to fog? Some authors think so. Two thousand years ago Pliny the Elder wrote about the Fountain Tree, or Holy Tree, on the island of El Hierro in the Canary Islands. From that time to at least 1800, the inhabitants obtained much of their water from fog that dripped from the leaves of one or more trees. In 1776, Gilbert White in England made astute observations on how trees collected water from the "swimming vapours" of fog.

Materials for fog collection

Fog droplets have diameters from about 1 μm to 40 μm. Drizzle drops have diameters from 40 μm to 500 μm (0.5 mm) and raindrops from about 0.5 mm to 5 mm. Because fog droplets are so small they have very low settling velocities and to a good approximation go wherever the wind blows them. This means that a fog collector should be a vertical surface. The wind simply blows the droplets against the surface. It cannot, however, be a solid surface or the wind will flow around the obstacle taking the droplets with it. The efficiency of the collection process improves with larger fog droplets, higher wind speeds, and narrower collection fibres. In addition, a porous medium with good drainage characteristics is required.

These needs are fulfilled by meshes of different designs. In most projects to date a double layer of polypropylene mesh has been used. The fibres are about a millimetre wide and the fibres of the mesh cover approximately 60 per cent of the surface area of the collector. The mesh is ultraviolet-protected and has a lifetime of about ten years in the mountains where it has been used. It costs US$0.25 per square metre in Chile and is available in other countries, from other suppliers, at a somewhat higher cost. A British polyethylene mesh with similar characteristics is also available in many parts of the world as is a rigid American mesh of different design. All of these materials can produce very good results.

Photo: Robert Schemenauer

A fog collector is simply a frame that supports a section of mesh in a vertical plane. The large, operational fog collectors are typically made of two supporting posts, and cables on which the mesh is suspended. In addition, there is a network of guy wires to support the posts, a plastic trough to collect the water, and pipes to move water from the troughs to a reservoir or cistern. The large collectors are usually 12 m long and 6 m high. The mesh covers the upper 4 m of the collector. This gives a collecting surface of 48 m^2 and typical water production rates from one collector of from 150 L day^{-1} (litres a day) to 750 L day^{-1} depending on the site. Sustained production rates over periods of two and one-half months in the Sultanate of Oman were as high as 70 L m^{-2} day^{-1} or 3360 L $collector^{-1}$ day^{-1}. The 48 m^2 fog collectors cost about US$400 each to build and arrays for villages number from 30 to 80 collectors. The 1 m^2 Standard Fog Collectors cost from US$100 to US$200 to build depending on the country and the materials.

Choosing a site location

Fog collection is a resource that should be evaluated in areas where other traditional sources of water, for example, surface water, wells or rainwater collection, cannot meet the needs of the people and where a water pipeline or desalination plants are impractical or too costly. The project costs are small, the technology simple, the water of very good quality, and the source sustainable for periods of hundreds or thousands of years.

Normally, fog formed on the ocean surface, or nocturnal radiation fogs in low-lying areas, will lack sufficient liquid water content or sufficient wind speeds for substantial water collection; therefore, this discussion will be limited to upland areas with fog produced by the advection of clouds over the terrain or, in some cases, by orographic lifting on the mountains.

The selection of a site for a fog collection project follows a logical process.

> First, identify a societal need for water.

There must be a community with a requirement for more water or cleaner water and conventional means are not able to meet the requirement. In some cases, the water is not needed for domestic purposes but rather for agricultural or forestry applications.

The next steps are as follows.

> To examine the meteorological records for the area; and, to consult with people living in the area as to their observations of fog on the mountains.

Then a more rigorous evaluation project is undertaken.

> Small 1 m^2 fog collectors are installed on the terrain features of interest.

These Standard Fog Collectors (SFC) measure the amount of water that can be collected at a site and define the seasonal variation in collection rates.

Finally, using the information available:

> A system of collection, transport, storage and distribution of fog water is designed.

The expected costs and expected benefits of a fog collection project are looked at before a decision is made to proceed. The process is somewhat akin to going into an area and deciding where and whether to drill a well for a community.

There are a number of meteorological and geographic considerations that are important in choosing a site:

> global wind patterns may result in a predominant wind

- direction,
- the altitude range of the clouds must be below the maximum terrain heights,
- a mountain range perpendicular to the prevailing winds and high enough to intercept the clouds is needed,
- in the case of coastal cloud decks, the mountain range should be within 5 or 10 km of the coast,
- the mountains or hills must have sufficient space for the fog collector array,
- there should be no major terrain obstacle upwind of the site, and,
- the microtopography on the ridge or mountain affects the fog collection rates; collectors are normally located on the crestlines of ridges or slightly upwind of the crestline.

Sustainability and climate change

The sustainability of a fog collection project depends on the persistence of the clouds that flow over the mountain where the site is located. Particularly in the case of coastal sites, these cloud decks are produced as a result of large- scale meteorological and oceanographic features, which one has reason to believe have been basically unchanged for thousands of years, for example, the east-Pacific subtropical anticyclone and the Humboldt Current.

Changes in sea surface temperatures or temperatures in the atmosphere can change the height of cloud bases or influence somewhat the extent of the cloud decks but there is no evidence that major changes will take place in coastal regions. Small changes in cloud base height are unlikely to be a problem for fog collection projects because sites are chosen to be in the middle of the foggy region on the mountain slopes and because it is not a difficult task to relocate the collectors should that ever need to be done.

The lifetime of the mesh on the collectors is about ten years and the lifetime of the other materials about twenty years, so there are periodic opportunities to adjust the sites. It should also be noted that if there were concerns about fog water inputs being modified due to climate change, the primary concern should be directed towards coastal and upland forests in temperate and tropical regions, since they depend to a large extent on fog as a water input.

Fog collection sites

Chungungo is a fishing village on the arid northern coast of Chile. In 1987, on the mountains a few kilometres inland, a project began to investigate the science and technology associated with fog collection. In March 1992 a pipeline was completed and the fog water, from 75 collectors measuring 48 m^2 each, began to flow down the mountain to Chungungo. The average production is 11,000 L day^{-1}. This is enough to provide each of the 340 villagers with more than 30 L per person per day. The water supply has changed the inhabitants' lives, broadened their diets, and enriched the community. The villagers now have their own water authority, charge for the water consumed, and maintain the water system. Periodic surveys of the villagers have shown them to prefer the taste and availability of the fog water to the more expensive trucked-in water they depended on before.

The project for Chungungo was a joint Chilean-Canadian effort. The Pontifical Catholic University of Chile, the University of Chile, and the Chilean National Forestry Corporation were involved. The majority of the funding for the project came from the International Development Research Centre (IDRC) in Ottawa, with substantial support also from Environment Canada and the Canadian Embassy in Santiago.

Funding sources have varied for other projects, but the IDRC and the Canadian International Development Agency have been involved in many of them. In recent years, support from the private sector for fog collection projects has increased greatly in importance.

As in Chile, there has been a history of small fog collection experiments along the Peru coast. The first intensive assessment of the fog collection potential took place in 1990 and subsequently there have been a number of both private sector and institutional projects. In 1993 the International Development Research Centre provided funding through a non-governmental organization, TECNIDES, for a large agricultural and forestry project for the community of Collanac on the edge of Lima, an area which receives only 5 mm of annual precipitation. For the last several years the Commission of European Communities has sponsored a scientific project in the southern coastal desert. The project uses fog water for irrigation of a plot of thousands of native and introduced tree seedlings and shrubs. The goal is reforestation of the coastal hills. The project is being carried out by a consortium of South American and European universities headed by the

Universidad de San Augustin in Arequipa, Peru.

The first operational fog collection project in Ecuador was at Pululahua just to the north of Quito. It was a joint effort of the Ecuadorean non-governmental organization Centro de Investigaciones Sociales Alternativas and the Fondo Ecuatoriano Canadiense de Desarrollo. A new project has just been completed at Pachamama Grande, which means "Big Mother Earth" in the Quechua language. Pachamama Grande is an indigenous community in the south of Ecuador at an elevation of 3700 metres. The local people are participating in the project from the beginning and are delighted at the prospects of having a clean water supply. This is the first project where private sector donations have played a major role in funding the fog water supply for a village.

Volunteers from a Canadian non-governmental organization, the Centre Canadien d'Étude et de Coopération Internationale, worked with the villagers to implement the project. The International Development Research Centre funded the initial technical site evaluation.

In the complexity of a project it is sometimes easy to lose sight of the simplicity of the water source and how basic water is to the needs of the people. But there are moments when the villagers themselves bring one back to reality: for example, when they call the spinning cups of the anemometers "butterflies" or when they tell you that even the animals got sick from drinking from the previous water source, a little canal by the village.

Namibia is the first African country in which the possibility of using fog collection as a water supply for indigenous peoples is being evaluated. There have also been scientific evaluations underway for several years in both the Canary Islands and South Africa. All show positive results. In 1989 and 1990 a major evaluation was undertaken in the Sultanate of Oman on the Arabian Peninsula. Very high fog collection rates were measured during the period June to September during the Southwest Monsoon. The limited collection period makes the technique perhaps more suitable to forestry applications in this location. Presently there are several evaluation projects underway in Mexico and a project with two sites in Nepal. The focus of these later projects is on domestic water supplies for rural areas.

Fog collection will not be the total answer to the world's water shortages. However, it is an example of how we can work with what nature gives us and of how developing and developed countries can pool their skills to initiate low-technology, sustainable water projects. Fog collection will complement other water supply systems not replace them.

The different aspects of the technology and the project results have been documented in the literature and it deserves strong consideration in regions that are arid or seasonally arid. There is much interest from individuals and organizations in many parts of the world but, as a non-conventional technology, there are obstacles with regard to obtaining funding for projects. Hopefully, this will change as recognition of the benefits of fog collection builds and more people have the opportunity to visit existing projects.

Further information

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Related meetings

First International Conference on Fog and Fog Collection, Vancouver, Canada, 19-07-98 to 24-07-98. **Details:** Sherry Kornblum, Environmental Communications International, PO Box 81541, 1057 Steeles Ave, West North York, Ontario M2R 2XI, Canada. Fax: 1-416-7394211. Email: robert.schemenauer@ec.gc.ca.

Previous article | Return to Tiempo index | Next article