Fog Collection as a Water Source For Small Rural Communities in Chiapas Mexico

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Abstract: There are many small rural communities with serious water supply deficiencies. The introduction of alternative technologies may represent a means of supplying water, perhaps from fog and rain, at a low cost. In the state of Chiapas, in southern Mexico, research is under way on the collection of fog water for human consumption. The preliminary results of this study are presented here. At the close of the first phase of the study (September 1994 to June 1995), the maximum monthly collection rate from fog was 121 $l/5m^2$ for March 1995. The maximum daily collection was registered during January and February of 1995 and was 3.6 l/m^2/day. However, the average monthly collection for January and February was barely 0.49 and 0.48 l/m^2/day. The feasibility of collecting fog in inland regions (mountains) was evaluated and it is estimated that with an average collection of 1 l/m^2/day and an exposed fog coalescence surface area of 2400 m^2, the daily collection could be 2400 liters, enough to provide 25 l/capita/day to each of the village's 96 inhabitants.

1. BACKGROUND

In Mexico, there are rural communities that due to their geographic location, climate and topography encounter difficulties in supplying water to the population. These communities are found in the states of Chiapas, Oaxaca, Guerrero, Veracruz, Puebla, and North and South Baja California. Generally, they are poverty areas. In the state of Chiapas, there are more than 16,000 of these rural communities of which 12,000 have fewer than 100 inhabitants. The lack of a constant water supply is most severe in the highlands of Chiapas where the population is made up mainly of indigenous groups. The communities are on mountainous terrain with a widely dispersed population. These characteristics combine to make the provision of public utilities, such as water, electricity and sewerage, difficult with the conventional means. Alternative technologies may well provide the solution for these economically depressed areas, specially through fog and rain collection.The combination of potability and low cost makes fog collection a serious alternative for rural areas where the weather factors make it possible (Schemenauer, 1992). Natural and artificial fog collection has been studied in 22 countries. In Chile, a small fishing community is exploiting the possibilities of fog collection (ibid). Considering the results of previous studies, the abundance of fog in the highlands of Chiapas, and the long-standing need for water, the Civil Engineering School of the Chiapas State University and the Mexican Institute of Water Technology began research in 1994 to evaluate the possibility of collecting fog to supply the needs of the communities. This collection system has been successful in Antofagasta (Chile), Atiquipa and Lachay (Peru) and on the Tenerife Island (Spain). The fog collectors used in these other sites were economical, easy to install and required a minimum of maintenance. The design of the fog collector is relatively simple. It has a wooden frame from 5 to 50 m^2 with two layers of polypropylene screening with 0.5mm diameter strands spaced 1.5mm apart. A collection canal is placed below the upright screen to receive the coalesced water. A hose or pipe carries the water to a container.

2. FOG COLLECTION

Fog is a colloidal system made up of solid particles and water droplets formed by the condensation of water vapor on hygroscopic nuclei. The volume of liquid water in fog varies from 10^{-4} to 2 g/m^3, with an average of almost 0.2 g/m^3. In clouds, the average volume of condensed water is slightly higher, between 10^{-2} and 4 g/m^3 (Mundo, 1995). However, the base of the cloud is usually several hundred meters above ground level, while fog is nearer the surface. In regions at a high altitude, such as the Chiapas highlands, clouds become fog because ground level is higher than the cloud base. As the cloud is moved by wind, water droplets are deposited on the obstacles encountered. This phenomenon is called **fog precipitation**. The collection of the water held in fog is a primitive technology. In the antiquity, wooden walls were placed on the roofs of houses for this purpose (Cereceda, 1995). In the Canary Islands, there is a community that has used this means of obtaining water for the last 2000 years (Schemenauer and Cereceda, 1994). Literature and information (usually in documents) can be found in 22 countries on four continents concerning natural and artificial fog collection (ibid). More recently, a project that was begun in 1988 to provide drinking water to Chungungo in Antofagasta in northern Chile was successful. The community installed 75 48-m^2 fog collectors that are now supplying 330 inhabitants with an average of 7200 liters daily (3 $l/m^2/d$). The water is conveyed through the mountains to the seaside village below (Cereceda, 1995). In Mexico, the first studies of fog (microphysics) were carried out by Garcia and Montañez (1990) from a motorized laboratory in the eastern Sierra Madre (Teziutlan, Puebla). Volgelmann (in Garcia and Montañez, 1990) also studied fog in this region as related to the development and maintenance of certain kinds of vegetation as well as the water balance in the area. However, the first project to study the potential use of fog water for human consumption in Mexico (in an inland region) was carried out by the Chiapas State University and the Mexican Institute of Water Technology (Mundo, 1995).

3. METHOD

This project was divided into three phases:

a) Evaluation of fog collection in the pilot areas.

b) Evaluation of other potential sites in the state, evaluation and description of weather conditions at the selected sites, pilot tests using standard collectors, geographic and topographic studies, social studies, fog water quality evaluation, fog microphysics and laboratory experiments (wind tunnel).

c) Technology diffusion and transfer.

First stage. The three principal characteristics for the pilot study sites were the presence of fog during a greater part of the year, an indigenous community of fewer than 100 inhabitants and a needed for a water supply. Most of the small communities that fulfilled these requirements were within the "conflict zone" of the armed uprising of January 1994. Two pilot projects were installed in communities outside of the area in conflict but which had similar climate and social conditions.

Second stage. At the site with the greater potential for fog collection, an automated weather station was placed to characterize the area climate. The geography of the zone was also characterized (Cereceda, 1995). Four additional pilot sites were identified for the installation of standard fog collectors: Zontehuitz, Yalentay, El Eden-2 and Oxchuc. Planning for the installation of the fog collectors is in progress. In conjunction with the Atmospheric Sciences Center of the Mexico City University (UNAM) field studies of fog microphysics were carried out using laser spectrometry with frontal dispersion and an optical array coupled to a data acquisition system. An experimental set up was designed and later installed at the IMTA's facilities to study and analyze the physical process of fog precipitation, and the influence and relationship between variables such as relative humidity, wind speed, turbulence and temperature, and the volume of fog precipitated (Mundo, 1995). A social study was prepared to analyze and create the conditions appropriate for acceptance, construction and maintenance of the new technology among the indigenous communities where it will be implemented.

4. PRELIMINARY RESULTS

The results presented here are those for the pilot site at El Eden-2 Ranch, located 33 km to the west of Tuxtla Gutierrez, at 16°43'N -93°17'W High in the mountains, the Ranch is on the northern border of the Grijalva River. The hypothesized source of the fog is the Gulf of Mexico (approximately 100 km north of the Ranch). Its humidity is increased by the orohydrography of the zone (Cereceda, 1995).

Results of tests in 1994. Testing was begun September 20, 1994. The average collections for the first three months are given in Table 1.

Table 1. Fog water collection from September to December 1994, Rancho El Eden

Month	Incidence of fog	Average collection (incidence, $l/m^2/d$)	Average monthly collection ($l/m^2/d$)
September	4	0.8461	0.1128
October	14	0.031	0.0142
November	9	0.157	0.0470
December	0	no data	no data

Results of tests in 1995. See Table 2 for the volumes collected from January to June. The maximum monthly collection volume was 121 $l/5m^2$, in March; the minimum was 0 $l/5m^2$ for May. The maximum one-day value was 3.6 $l/m^2/d$ in January and February. However, the averages for these two months were 0.49 $l/m^2/d$ and 0.48 $l/m^2/d$, respectively.

Table 2. Fog water collection from January to June 1995, Ranch El Eden

Month	Total volume collected (l)	Average volume collected ($l/m^2/d$)
January	76.34	0.49
February	67.62	0.48
March	121.18	0.78
April	26.31	0.17
May	0	0
June	25.71	0.17

From the information in Tables 1 and 2, it may be seen that fog occurs more commonly from September to March, the most appropriate time for fog collection. During the other six months, there was no fog with certain exceptions in March and June.

5. DISCUSSION

It should be pointed out that daily registries were not made of the collection or of the incidence of fog. *The feasibility of fog collection* in this inland zone was clearly shown. The average collection volumes were relatively low when compared with other coastal regions, such as northern Chile (3 $l/m^2/d$). Possibly by relocating the fog collectors at higher points (to penetrate deeper within the cloud) and in clearings where the wind speed could exceed 5 m/s) a collection rate of 1 $l/m^2/d$ could be reached. Although this rate is still relatively low (this is a mountainous inland region) when combined with an exposed surface area of 2400 m^2 (48 50 m^2-collectors), total collection could be 2400 liters per day, which for a population of 96 inhabitants would provide an average of 25 l/capita/day. Even in the case that the average collection were to be the 0.46285 $l/m^2/d$ average found from September 1994 to March 1995, an exposed surface area of 2400 m^2 would still provide a 44 persons with 25 l/capita/day.

6. CONCLUSIONS

In view of the demographic dispersion of rural communities with fewer than 100 inhabitants in areas of difficult access, such as the Highlands of Chiapas, the use of alternative technology to supply water offers feasible solutions. In these cases, the economic factor is fundamental. This technology can be adapted to the socio-economic and physical conditions of the region. Several conclusions can be drawn from this first phase of research:

- Pilot studies indicate that fog water precipitation is feasible.
- Fog collection is feasible in mountainous inland regions
- At the pilot site, average collection was 0.49 $l/m^2/d$, with a maximum of 18 l/5 m^2/d, and encourage value for the project sites.
- This rate may increase to 1 $l/m^2/d$, at an adequately selected site where wind speed may reach 5 m/s.
- At an average collection rate of 1 $l/m^2/d$, an exposed collection surface area of 2400 m^2, and average collection volume of 2400 l/day would supply a small community of 96 inhabitants with 25 l/capita/day.

To provide a more complete solution to the water shortage in these communities where the average annual rainfall is 1200 mm, a rain catchment system could be implemented.

As part of the second phase of the project (instrumentation), laboratory studies have been started to define the relationship and influence of the principal climate parameters in fog precipitation: relative humidity, wind speed and environmental temperature. A wind tunnel was designed to reproduce and study the fog precipitation phenomenon in a semi-controlled environment.

7. ACKNOWLEDGEMENTS

We would like to thank Arturo Valverde-Lara and Jose Luis Gallegos, students at the Civil Engineering Faculty, Chiapas State University for their contribution to the field studies during the first phase of the study.

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