The Collection of Cloud Water in Chile for Human Consumption and Agricultural Usage

by

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1. Introduction

The lack of fresh water for human consumption, agricultural purposes and a variety of industrial uses is increasingly becoming a problem throughout the world. Shortages arise in highly developed countries (e.g. the southwestern United States) as well as in areas lacking the resources to attempt costly remedies for the lack of water (e.g. north central Africa). Shortages arise because of over utilization of existing ground water or because of a lack of replenishment of the ground water due to short or long term decreases in precipitation. Traditional solutions to the problem have been to better utilize surface runoff with dams and altered cropping practices, to consider limiting or moving populations and to initiate rainfall or snowpack augmentation programs. There are many reasons why these solutions may not be practical in a particular location and as a result new ideas tailored to a particular locale should be pursued.

Chile is a country of geographical and climatological extremes. Its 4200 km length is sandwiched between the Andean Cordillera and the Pacific ocean with an average width of only 175 km. The northern part is probably the driest region on the globe while the southern region is the wettest extratropical region in the world (Miller, 1976). There is a lack of good groundwater in northern Chile and few rivers that can be used for irrigation and thus though the region is blessed with warm weather throughout the year there is little potential for agriculture. This shortage of water for drinking, sanitary and agricultural purposes is a contributing factor to the movement of people from the coastal fishing villages to the larger cities.

In the northern third of Chile and in Peru the weather is dominated by the Pacific anticyclone throughout the year. This produces a light southerly or southwesterly flow in the lower kilometer of the atmosphere and results in a stratus or stratocumulus deck that extends a few hundred kilometers out over the ocean. Fog events are frequent at altitudes between 500 and 1000 m in the coastal mountains (these high altitude fog events are called camanchacas) where the terrain intercepts the low clouds. Where there is vegetation in this zone it can intercept some fog water and the fog drip can sustain the plant. The importance of fogs as sources of water in certain locations has been recognized for a considerable time. Kerfoot (1968) and more recently Schemenauer (1986) have reviewed the literature pertaining to deposition rates of water from fogs. The rates can be substantial, equalling or exceeding the amounts of rainfall in areas with rain and providing the only sources of water in some desert areas.

Interest in removing water from the camanchacas has existed for 30 years or more in Chile. Most of the work has been done in small projects which are described in institutional or university reports. Major projects have not been undertaken due to both insufficient funding and lack of continuity in funding. This paper will deal with the topographical factors relevant to the formation of camanchacas and the collection of water from them. It will also present some recent data from field experiments in Chile.

2. Topographical influences on fog water collection

Although the presence of the camanchaca is a general phenomenon along the northern coast of Chile, its behavior is controlled by the physiography of the coast. Some conclusions in this regard have been presented in Carvajal (1982), Larrain and Cereceda (1982, 1983) and Cereceda (1983).

The macrotopography determines the path the air takes as it moves from the ocean to the continent and at the same time provides the barrier to intercept the cloud. On the regional scale there are 4 aspects of relief that are important. First, there must be a mountain range with an average altitude of 500 m or more. This will be high enough to control the boundary layer flow and to intercept the camanchacas. Second, the principal axis of the range should be perpendicular to the predominant wind direction (southwest) at the altitude of the camanchacas. Third, the preferred site location is on a mountain range close to the coast. This minimizes the loss of cloud water due to evaporation before the clouds reach the site. Fourth, the presence, to the east of the mountain range, of a broad basin that produces an ascending region of warm air due to high daytime heating. This serves to suck the oceanic air through the mountains.

Once a mountain range is selected as an appropriate place for the presence of fog, and hence of potential value for the capture of fog water, there are some features of relief that should be considered for the location of the collectors. The altitude range where maximum amounts of water are collected is between 600 and 900 m. Fig. 1 shows the amount of water collected (1981, 1982) by passive fog collectors at 7 altitudes on Cordon Sarcos (near El Tofo) as a function of altitude. Maximum collection was at 700 m. The percentage of ground covered by shrubs also shows a broad peak at mid-levels as do the shrub density per 100 m^2 (not shown) and the percent of organic matter in the soil (not shown). The relationship between water availability and herbs is not as clear.

The geomorphology determines the flow of the air mass that is generated over the ocean and advances inland. The coastal terrain, with its particular topography is the natural interceptor of fog, and different forms of the relief influence in a direct way the speed and direction of the flow and the potential capacity for water collection. An intensive field program which will allow for the testing of some of these guidelines will be conducted in November 1987 and again in 1988.

3. Water availability

If one applies the daily mean collection rate (CONAF 1985) for a 40 m^2 nylon mesh collector, 10 L $m^{-2} d^{-1}$, to 60 collectors which are in clouds almost daily for 6 months of the year and about one-half of the time for the other 6 months (Miller, 1976), the total amount of water collected would be 6.6×10^6 L y^{-1}. Using a small reservoir this water could be spread out over 365 days giving 1.8×10^4 L d^{-1}, or 40 L d^{-1} for each of the 450 people in the village of Chungungo. This is a substantial amount of water for people who presently use about 7 L d^{-1} per person of poor quality water that is trucked in at a considerable expense. The cost of the water is discussed in detail in Schemenauer et al. (1987). Amortized over five years the cost of the cloud water is about \$1.10 U.S. m^{-3}. This is considerably cheaper than the well water which is presently trucked in at a cost of ≈ \$8.00 U.S. m^{-3}. The cloud water is also of much better quality than the well water.

4. Conclusions

Based on past work in Chile and on calculations of water availability it appears that the camanchacas may provide a significant new source of water for the arid north of Chile. A large number of 40 m^2 mesh collectors can be located on the coastal mountains near small villages and potentially increase the current meagre water supply tenfold. This has important implications not only for improving the quality of village life and beginning agricultural production in the desert but also for reversing the migration to the cities and for the reforestation of the hillsides. Once a careful site selection study has been completed, the installation of the collectors is relatively low cost and straight forward. Maintenance is minimal and could be handled by local populations. The water itself is clean and the system free of possible contamination.

There are of course no reasons why fog water can be used as a water supply only on the west coast of South America. There is a modest body of literature to suggest that other continental margins and some island locations with little rainfall could benefit in a major way from the application of this technology.

References

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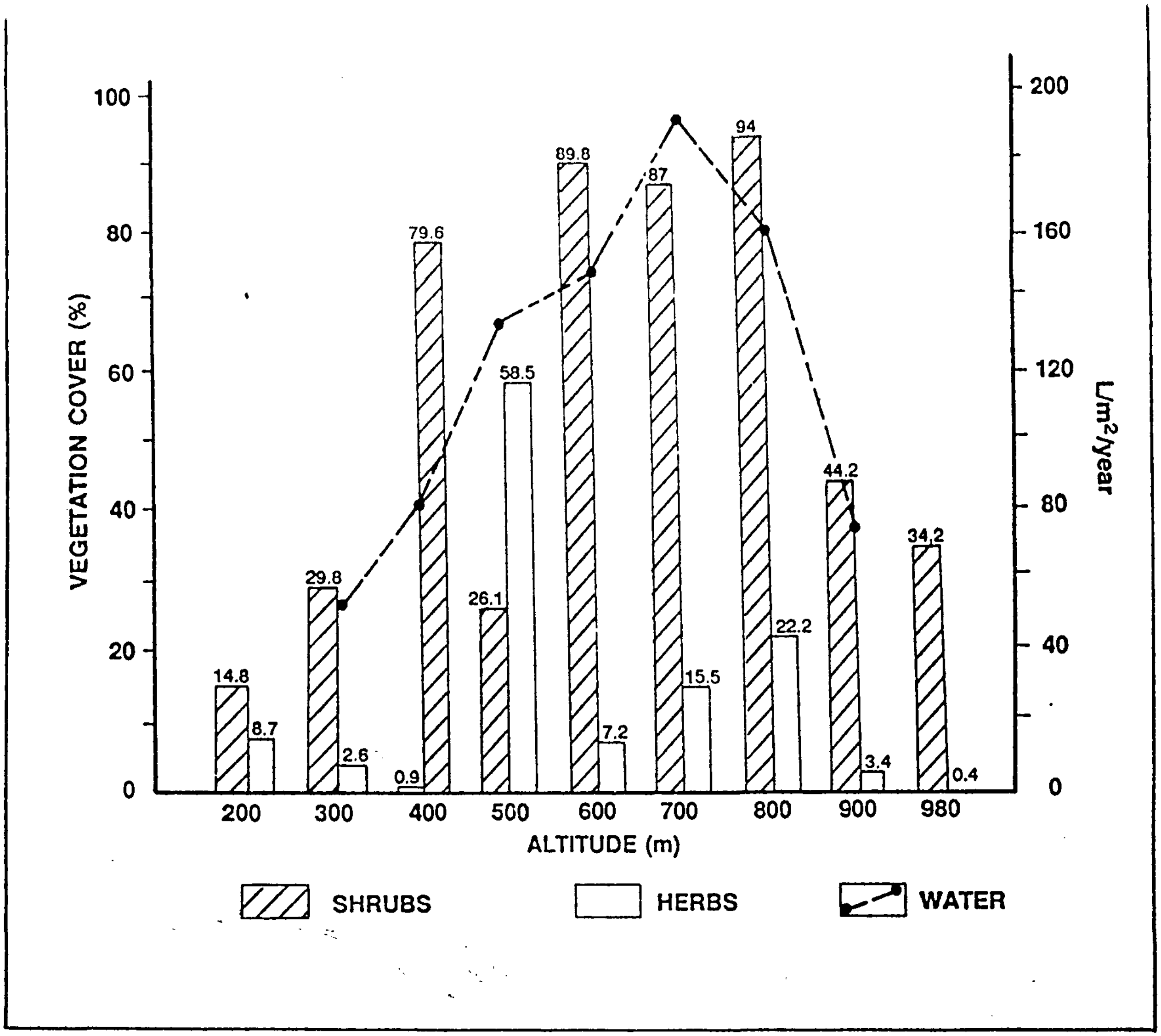
Figure Captions

Fig. 1 Water collected per m^2 per year on Cordon Sarcos near El Tofo as a function of altitude. Percentage of ground covered by shrubs and herbs is also shown.



VEGETATION COVER (%)
0
20
40
60
80
100
L/m²/year
0
40
80
120
160
200
14.8
8.7
29.8
2.6
0.9
79.6
26.1
58.5
89.8
7.2
87
15.5
94
22.2
44.2
3.4
34.2
0.4
200
300
400
500
600
700
800
900
980
ALTITUDE (m)
SHRUBS
HERBS
WATER

Fig. 1