

DOI: <https://doi.org/10.56712/latam.v4i2.1023>

Fog water traps as a low-cost alternative source of wáter in coastal desert areas of the Pacific

Trampas de agua de niebla como fuente alternativa de agua de bajo
costo en zonas desérticas costeras del Pacífico

Luis P. Morales Vergara

luis.morales@engie.com

<https://orcid.org/0009-0006-1569-0405>

Corporate Affairs Specialist, Engie Energía Chile
Atacama – Chile

Ricardo Cunha Lima

ricardo.cunha@uda.cl

Centro de Investigaciones Costeras, Universidad de Atacama (CIC-UDA)
Atacama – Chile

Estefanía Bonnail

estefania.bonnail@uda.cl

Centro de Investigaciones Costeras, Universidad de Atacama (CIC-UDA)
Atacama – Chile

Carlos González Allende

carlos.gonzaleza@uda.cl

Centro de Investigaciones Costeras, Universidad de Atacama (CIC-UDA)
Atacama – Chile

Artículo recibido: 08 de agosto de 2023. Aceptado para publicación: 22 de agosto de 2023.
Conflictos de Interés: Ninguno que declarar.

Abstract

Water scarcity is the most common concept associated with the desert. The Atacama Desert is worldly known as the aridest desert on Earth. However, some populations are established in this area, requiring water for living that promotes the search of alternative water sources, as fog catchers taking in advance the regional fog event known as Camanchaca. During 2015, the construction of fog trap units was carried out on a hill in the Falda Verde sector in Chañaral (North Chile). In the design of these new fog trap units it was considered to improve the anchoring system and the distribution and angles of the clamping tensioners in order that the structure could withstand the maximum wind speeds that have been registered in the area, while recording the water accumulated by these units during a period of 12 months determined an average catchment of 22 liters of water/m² per month.


Keywords: fog water cácher, polypropylene mesh, atacama's desert, environmentally friendly collectors, water source

Resumen

La escasez de agua es el concepto más común asociado con el desierto. El Desierto de Atacama es mundialmente conocido como el desierto más árido de la Tierra. Sin embargo, en esta zona se establecen algunas poblaciones que requieren agua para vivir lo que promueve la búsqueda

de fuentes alternativas de agua, como atrapanieblas adelantándose al evento regional de niebla conocido como Camanchaca. Durante 2015 se realizó la construcción de unidades trampa de niebla en un cerro del sector Falda Verde en Chañaral (Norte de Chile). En el diseño de estas nuevas unidades trampa de niebla se consideró mejorar el sistema de anclaje y la distribución y ángulos de los tensores de sujeción para que la estructura pudiera soportar las máximas velocidades de viento que se han registrado en la zona, mientras se registraba el agua acumulada. por estas unidades durante un período de 12 meses determinando una captación promedio de 22 litros de agua/m² por mes.

Palabras clave: colector de agua de niebla, malla de polipropileno, desierto de atacama, colectores ecológicos, fuente de agua

Todo el contenido de LATAM Revista Latinoamericana de Ciencias Sociales y Humanidades, publicados en este sitio está disponibles bajo Licencia Creative Commons . 

Como citar: Morales Vergara, L. P., Cunha Lima, R., Bonnail, E., & González Allende, C. (2023). Fog water traps as a low-cost alternative source of wáter in coastal desert areas of the Pacific. *LATAM Revista Latinoamericana de Ciencias Sociales y Humanidades* 4(2), 5866–5875. <https://doi.org/10.56712/latam.v4i2.1023>

INTRODUCTION

The fog or mist is a geophysical and geographical phenomenon that occurs in almost all areas of the world. In the Chilean territory, fog is frequent on the coast and high Andean mountains. It is defined as a mass of air composed of tiny drops of water (1 to 40 microns), which because they are so light do not fall, but remain suspended at the mercy of the wind if they are on the surface of the continents or oceans, while if they are in the atmosphere they are called clouds (Cereceda et al., 2008).

One of the causes of the formation of clouds and fog is due to the presence of anticyclones or high-pressure centers. The Southeast Pacific Anticyclone is present off the coasts of Ecuador, Chile and Peru. This produces a thermal inversion by subsidence, that is, air descending from the upper atmosphere that is heated by compression. This is due to the adiabatic heating of the intermediate layers of the atmosphere, caused by the downward movement of air from the high-pressure centers (Henderson-Sellers and Robinson, 1986).

The capture of fog water uses a simple and sustainable technology, whose implementation has been increasing in recent decades in different regions of the world (Olivier, 2002; Mousavi-baygi, 2008; Fessehaye et al., 2014; Carrera-Villacrés et al., 2017).

On the coast of the province of Chañaral, Atacama Region, Chile, fog occurs daily on the southwestern slope of the Pan de Azúcar National Park, with an hourly frequency that varies depending on seasonality. In these sectors, the construction of fog catchers was developed by an organization initially formed by local fishermen. In the sector, an average fog water catchment of 1.46 L / m² day was determined by Larraín et al. (2002), which aroused interest in the development of mist water collection techniques in the area of Falda Verde.

The aim of the current study was to determine the best parameters construction of fog catchers in Antena 2 (Chañaral, north Chile) to obtain the greatest volume of fog water accordingly winds in the study area. Fog water was monitored for a year to observe the efficiency improvement of the low-cost collector systems.

MATERIAL AND METHODS

Study area: Chañaral coast fog features

The mist present on the coast of Chañaral is formed by the orogenic advection process. This is very common in the coastal cordons of northern Chile; it is formed from a stratocumulus cloud that is generated in the sea hundreds of kilometers from the coast. It remains practically constant presence, but variable in altitude, approximately between 500 and 1200 meters above sea level. This cloud is displaced by the wind from the sea to the coast and the Cordillera de la Costa (advection). There it is intercepted by the slopes and summits of the cliffs and hills, transforming into the fog, which is why it is defined as a "cloud at ground level" (Cereceda et al., 2008). In fact, the elevation between the coast of Chañaral and the summit of the hill Falda verde is 1000 m above sea level, which allows the capture of fog water.

According to the Chilean Navy Meteorological Service winds chart, the coast of the Chañaral province has a predominance of southwesterly wind, with average speeds of 10 knots, reaching a maximum of 40 knots. The speed or force of the wind is the main factor that influences the greater or lesser potential of fog water collection. In general, this is explained in that while there is more wind, more water droplets will pass through the mesh that intercepts the fog, which will be collected by said surface (Regalado and Ritter, 2016, 2017).

The mountainous ground of the Falda Verde hill is composed of sedimentary and igneous qualification rocks. The slope of the top of the hill has an angle of 40°. The slopes have great importance as a determining variable of the water collection. First, they define the trajectory of

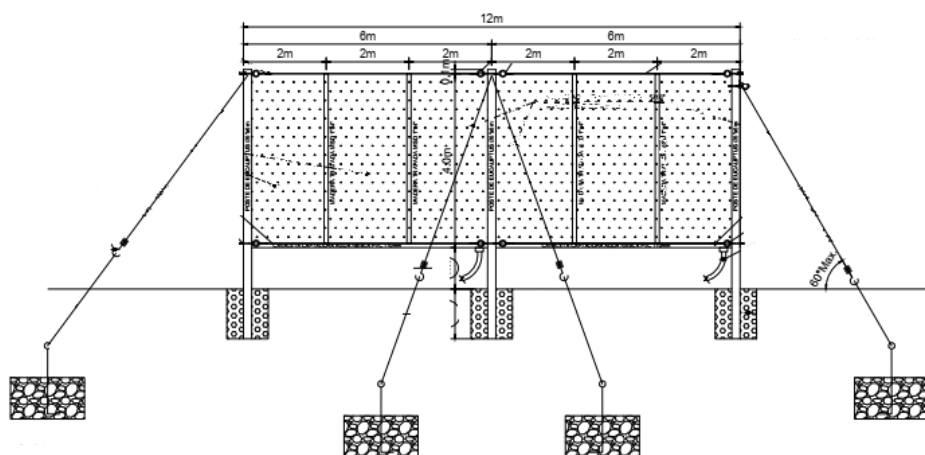
the winds, which in turn influence the arrival of cloudiness in the mountains. Second, they determine the feasibility of installing fog catchers in their peaks (Cereceda et al., 1992). Another additional component of the slope of the hill is the contribution in kinetic energy that is obtained with the height difference between the summit and the slope of the hill. This allows the energy saving of three pumps of 2.5 HP, which could contribute to a culture system with non-conventional renewable energy.

Design and construction of fog catchers

Each double unit of fog catchers (two cloths of 6 m length each) was designed for a capacity to generate 1.46 liters of water per square meter of mesh (Fig. 1). This water catchment system was installed on a summit of the Antena N° 2 Falda Verde hill, on a hill surface with a maximum inclination of 40°. The fog catchers were oriented in such a way that they could receive frontally the predominant SW wind in the area.

Figure 1

Design for the construction of the Falda Verde double trap unit



Pole foundations and tension anchors

The supports of each fog trap cloth were established in foundation dies based on soil-cement and boulders with a proportion of 50% stones and 50% cement floor, whose materials used corresponded to those available from the same hill and with a minimum dosage of three bags of cement per cubic meter of soil. The foundation for the tension anchors and winds (galvanized steel cables) was constituted of buried gabions with the same soil-cement and boulders filling in the same previous proportion.

Support pillars

As supporting pillars for each double trapping unit, 150 mm diameter x 6 m height wooden poles were used located in line and every 6 m between them, which were covered on all sides with a layer of asphalt primer (Igol Primer®) and two waterproofing paint finishing layers (Igol Denso®). Each pillar of support was buried at a minimum of 0.75 m deep, thus guaranteeing a meter of height measured from the ground for the placement of the mist water receiving gutter and 4 m high, after the gutter, for the installation of Raschel mesh (polypropylene mesh).

Fog water collection system

The water collection system consisted of a polypropylene mesh, Raschel brand Coresa® brand of 50% shade coefficient and double layer, which has protection against UV radiation and useful life of approximately ten years. The dimensions of each cloth were 4 x 6 m, internal measurements of the frame; the polypropylene fiber of the mesh used was 1 mm wide. This mesh was woven in a triangular pattern with spacing between the horizontal lines of 1.3 cm. The mesh was placed horizontally tense and the fibers of the triangular patterns in a vertical plane. The mesh was supported in its upper and lower part by galvanized or stainless-steel cables covered by 125 mm diameter polypropylene and was sewn with both the upper and lower cable, using polypropylene yarn of 2 mm diameter.

Wood supports

Treated and dimensioned wood of 25 x 100 mm, two per cloth of fog catchers. This wooden reinforcement was located 1 m above the ground at the most unfavorable point. The bolts that were used as support and union of the vertical frame table of the mesh were 125 x 250 mm hot galvanized steel, separated from each other by 1.25 m. The vertical supports of the Raschel mesh that were used to form the vertical frame of the fog catchers were treated wood of 25 x 100 mm. In the central post, supports were installed in duplicate. The mesh, prior to its placement, wrapped the board with one turn and was secured by a seam with a 2 mm polypropylene thread. The tables were installed with the function of keeping the Raschel grid fixed vertically.

The wood was protected against moisture on all sides with a layer of asphalt primer (Igol Primer®) and two layers of waterproof paint finish (Igol Denso®) to prevent its rapid deterioration by being exposed in an open area.

Tensioners

The horizontal tension cables that were used to form the frame with the vertical boards were galvanized steel 9.5 mm coated with plastic-type PVC. These, at one end, considered a 125 mm hot-dip galvanized steel tensioner like all tension cables. At intervals of 2 m (one third) in the total length of the fog-trapping cloth, a vertical reinforcement was included hanging from the upper and lower tensioner cables, equal in length to the mesh. In each extreme pillar of the fog catchers, a support of 3 tensioners of galvanized steel of 8 mm with a plastic coating of the factory, connected by the superior part of the post was incorporated. In the central pole, 4 tension cables were used (two to windward and two to leeward).

The tensioning cable was connected to the connection element with the base, anchoring by means of a galvanized tensioner 125 mm hook - eye for 125 mm steel cable. The cable ties to the tensioner that were used were by turn by the eye and two galvanized steel clamps for 8 mm cable.

Fog water reception channel

Immediately below the mesh, the channel of reception and pre-accumulation of mist water was located. The gutter that he used was made of hydraulic PVC-C10 material, of semicircular shape with a cross-section of 110 mm in diameter, open throughout its length and supported by the galvanized steel cable of 9.5 mm corresponding to the lower frame of the catch fog. The gutters were joined with PVC adhesive type Vinilit® 101 which considered caps on both ends of it and for each channel cloth. The windward side of the gutter was placed 2 cm in front of the frame and at the same height as the lower edge of the frame. The back part of the gutter extended 8 cm behind the frame to catch the drops that could be detached from the frame in strong winds. The distance between the ground and the receiving channel of mist water was maintained at a maximum 1 m high above ground level. The bottom line of the gutter was maintained with a slope of 1 % to drain the water to one end, where an opening and discharge was installed with

connection to a 50 mm diameter of HDPE pipe. This design allowed the gutter to collect all the fog water and the drizzle that hits the fog catchers, having a substantial front area that can act as a direct collector of rain and drizzle.

Channeling system and transport of fog water

In the water conduction from the gutters to the sedimentation chambers, a 50 mm HDPE pipe was used, and it was used to transport the water from the chambers to the accumulation system at the foot of the hill. Special care was taken in the joints of the pipes to avoid leakage losses. The fog water transport system was constituted by 3 polypropylene drums with bolted cover, each of 50 L capacity and connected to each other by the HDPE pipe. These drums were distributed along the slope of the hill as sedimentation chambers, until reaching the mist water accumulation system located at the base of the hill. Each drum had an entrance through the top of the drum, 5 cm below the level of the lid and with a discharge elbow. The water outlet was located 18 cm above the floor of the chamber and included an elbow with removable polypropylene filter type Inox 55 x 80 mm, which retained particles of 1000 microns, at the vertical entrance of the elbow. In each of the drums, a U-type ventilation of minimum 25 mm in diameter was considered; this had a bronze or stainless-steel mesh at the outer end to prevent the entry of vectors into the drum.

RESULTS AND DISCUSSION

As populations increase and conventional water supplies are overexploited or contaminated the problem with the demand for freshwater globally will continue to grow (Schemenauer and Joe, 1989). The demand for freshwater has many political, social and economic problems, The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) now estimate that, although progress has been made, 605 million people worldwide will still be without access to safe drinking water in 2015 (WHO, 2012).

An alternative source of water is the fog or mist, used extensively in ancient times but largely ignored by water provision authorities (Olivier 2002). Many experiments have been conducted indicating the considerable potential of fog as a water source.

In South Africa, during 1969/70, Schutte (1971) implemented two large fog screens, constructed from a plastic mesh and measuring 28 x 3.6 m each, were erected at right angles to each other and to the fog- and cloud-bearing NE and SE winds. During a 15-month period, from October 1969 to December 1970, the screens collected an average of 31,000 L of water per month i.e. approximately 11 L/m² d. In another study, run in northern Chile in 1987, 75 fog collectors, each measuring 12 x 4 m were erected on a hill. According to reports, production rates vary from zero on clear days to a maximum of 100,000 L/d (Schemenauer et al., 1988; Schemenauer and Cereceda, 1992, 1994).

Previous data from the same study site found that the monthly water yield could be as high as 43.8 L/ m² of collecting surface (Larraín et al., 2002). Meanwhile, in our results, the measurement of fog water collection has been made from August 2015 to July 2016, with volumes ranging from 0 to 9,000 liters per month. The months of absence of catchment were January and February of 2015, while the highest monthly collection was in the month of August 2015. The average monthly fog water collection was 22 L/ m² (Table 1).

Table 1

Fog water collected (in L/month) in the sector of Falda Verde, Chañaral (Atacama's Region)

2015		2016								
Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	Jul				-	-	2000	8000	4900	4300
9000	5000	6000	5600	5000						
	2000									

CONCLUSIONS

The current technology represents a significant risk investment, but the pilot project presented here, first carried out to quantify the potential rate and yield that can be anticipated from the fog harvesting rate and the periodicity of the fog within the area, showed great potential.

Despite this, it is important to care not only with yield but with the water quality too. In recent analysis (Bonnail et al., 2018) fog water has failed to meet drinking water quality standards because of some minerals derived from the mining sector.

Water scarcity problem urges to map an atlas that shows an alternative source of water. So, to be this possible is necessary for planning the use of land without risk by exposing current water resources.

Acknowledgments

Thanks are due to all members from Agrupación Atrapaniebla for their valuable help at the experimental station. This work was supported by Fondo de Incentivo a la Competitividad, Gobierno Regional (GORE) Atacama (BIP code 30337674/2016).

Conflicts of interest/Competing interests

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Ethics approval

Not applicable

Consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

All data and information were archived under reports by Regional Government of Atacama, Chile.

Code availability

Not applicable

Authors' contributions

Conceptualization, R.C.L. and L.P.M.V.; methodology, L.P.M.V.; validation, R.C.L., C.G.A. and E.B.; formal analysis, R.C.L.; investigation, R.C.L.; resources, C.G.A.; data curation, R.C.L.; writing—original draft preparation, R.C.L.; writing—review and editing, E.B.; visualization, L.P.M.V.; supervision, L.P.M.V.; project administration, R.C.L.

Supplementary Materials

Video S1: Fog being trapped in Falda Verda hill after installation of technical improvements.

REFERENCES

Bonnail, E.; Lima, R.C.; Turrieta, G.M. (2018). Trapping fresh sea breeze in desert? Health status of Camanchaca, Atacama's fog. *Environmental Science and Pollution Research*, <https://doi.org/10.1007/s11356-018-2278-6>

Carrera-Villacrés, D.V.; Robalino, I.C.; Rodríguez, F.F.; Sandoval, W.R.; Hidalgo, D.L.; Toulkeridis, T. (2017). An Innovative Fog Catcher System Applied in the Andean Communities of Ecuador. *Transaction ASABE*, <https://doi.org/10.13031/trans.12368>

Cereceda, P., Schemenauer, R.S., Suit, M. (1992). An alternative water supply for Chilean coastal desert villages. *International Journal of Water Resources Development*, <https://doi.org/10.1080/07900629208722533>

Cereceda, P., Larraín, H., Osses, P., Farias, M., Egaña, I. (2008). The climate of the coast and fog zone in the Tarapacá Region, Atacama Desert, Chile. *Atmospheric Research*, <https://doi.org/10.1016/j.atmosres.2007.11.011>

Fessehaye, M., Abdul-Wahab, S.A., Savaged, M.J., Kohler, T., Gherezghihere, T., Hurnic, H. (2014). Fog-water collection for community use. *Renew Sust Energy Rev*, 29, 52–62, <https://doi.org/10.1016/j.rser.2013.08.063>

Henderson-Sellers, A., Robinson, P. J. (1986). *Contemporary climatology*: Harlow, Essex: Longman Scientific & Technical, New York: Wiley, 439 p.

Larraín, H., Velásquez, F., Cereceda, P., Espejo, R., Pinto, R., Osses, P., Schemenauer, R.S. (2002). Fog measurements at the site "Falda Verde" North of Chañaral compared with other fog stations of Chile. *Atmospheric Research*, [https://doi.org/10.1016/S0169-8095\(02\)00098-4](https://doi.org/10.1016/S0169-8095(02)00098-4)

Mousavi-baygi, M. (2008). The implementation of fog water collection systems in Northeast of Iran. *International Journal of Pure and Applied Physics*, 4 (1), 13–21,

Olivier, J. (2002). Fog-water harvesting along the West Coast of South Africa: a feasibility study. *Water SA*, <https://www.ajol.info/index.php/wsa/article/view/4908/69355>

Regalado, C.M., Ritter, A. (2017). The performance of three fog gauges under field conditions and its relationship with meteorological variables in an exposed site in Tenerife (Canary Islands). *Agricultural and Forest Meteorology*, <https://doi.org/10.1016/j.agrformet.2016.11.009>

Regalado, C.M. and A. Ritter. (2016). The design of an optimal fog water collector: A theoretical analysis. *Atmospheric Research*, <https://doi.org/10.1016/j.atmosres.2016.03.006>

Schemenauer, R.S., Fuenzalida, H., Cereceda, P. (1988). A neglected water resource: the Camanchaca of South America. *Bulletin of American Meteorological Society*, <https://doi.org/10.1175/1520-0477>


Schemenauer, R.S., Joe, P.I. (1989). The collection efficiency of a massive fog collector. *Atmospheric Research*, [https://doi.org/10.1016/0169-8095\(89\)90036-7](https://doi.org/10.1016/0169-8095(89)90036-7)

Schemenauer, R.S., Cereceda, P. (1992). The quality of fog water collected for domestic and agricultural use in Chile. *Journal of Applied Meteorology*, [https://doi.org/10.1175/1520-0450\(1992\)031<0275:TQOFWC>2.0.CO;2](https://doi.org/10.1175/1520-0450(1992)031<0275:TQOFWC>2.0.CO;2)

Schemenauer, R.S., Cereceda, P. (1994). A proposed standard fog collector for use in high elevation regions. *Journal of Applied Meteorology*, [https://doi.org/10.1175/1520-0450\(1994\)033<1313:APSFCE>2.0.CO;2](https://doi.org/10.1175/1520-0450(1994)033<1313:APSFCE>2.0.CO;2)

Schutte, J.M. (1971). Die Onttrekking van Water uit die Lae Wolke op Mariepskop. Technical note no. 20, Division of Hydrological Research, Department of Water Affairs, Pretoria.

WHO. (2012). UN-Water Global Analysis and Assessment of Sanitation and Drinking- Water, World Health Organization, pp. 112.

Todo el contenido de **LATAM Revista Latinoamericana de Ciencias Sociales y Humanidades**, publicados en este sitio está disponibles bajo Licencia [Creative Commons](#) .