

Fog Collection Evaluation and Operational Projects in the Hajja Governorate, Yemen

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A fog collection project has been carried out in the Hajja Governorate of the Yemen Arabic Republic. Twenty-six 1 m^2 Standard Fog Collectors (SFCs) were constructed with locally available materials, except for the mesh which was imported, and local workmanship. These SFCs were installed in December 2002 and January 2003. Nineteen different sites were chosen and data from 1 January 2003 to 31 March 2003 were obtained. The best sites averaged 4.5 liters of water per square meter of mesh per day over the three month winter period, which is a very good water production rate. The fact that two sites had fog water collection on every day in March is notable and, in itself, points to the potential importance of the fog collectors as a water source. Measurements with the SFCs were made from 1650 m to 2800 m elevation, with the best collection rates being found from 2000 to 2200 m. Subsequently, 25 large (40 m^2) fog collectors were built in January 2004 and grouped in arrays to provide water for village homes. Production from the collectors is estimated to be 4500 L day^{-1} . Both the evaluation and operational projects will be described in detail in the paper.

1. INTRODUCTION

Discussions in 2002 led to an agreement to conduct an evaluation of the fog collection potential in the Hajja Governorate of the Yemen Arabic Republic. This is a region bordering on the Red Sea located to the northwest of the capital Sanaa. The people in the rural areas of Yemen have a major need for clean drinking water in the winter months of December to March. This period is outside the yearly rainy season, which extends from April to August. The field work was carried out using fog collection protocols and instrumentation that have been developed in Chile (Schemenauer and Cereceda, 1994a; Schemenauer and Cereceda, 1994b) and subsequently used in many other countries.

To be successful, all projects must involve the people who will benefit from the water provided. This is true even of feasibility studies such as that conducted in the Hajja governorate in 2003. ICS Hajja had a presence in the governorate for two years and had well established links to Yemeni NGOs, especially the Jama'iyya Mustaqbal, who helped to implement this study. Meetings with representatives from the national NGOs and community leaders occurred primarily at the beginning of the project in order to discuss the project and the assistance that would be required from the people of the area. Under the

supervision of Khalid Al Aliyi, head of the Jama'iyya Mustaqbal, the 26 SFCs were constructed in workshops in Hajja city, using a manual provided by FogQuest. By mid-January, the final locations for the 26 SFCs were chosen and the collectors were installed. FogQuest briefed the people involved on the concept of fog collection, how the collectors worked and on the benefits that the fog collectors could bring through the provision of clean water for their families. Forms were produced in Arabic and discussed with the people who would record the measurements. Each person making field measurements had the use of the fog collector demonstrated after installation and continuous visits occurred from ICS to ensure the quality of the data. The field work went very well. There were some errors and omissions in the data records that were identified when the data were transferred to Chile for processing; however, the vast majority of the fog collector data, weather observations, and rainfall data were of good quality. The results have been reported in detail by Leibbrand, Schemenauer and Osses (2003).

2. THE FIELD EVALUATION PHASE

The SFCs were preferentially sited on ridges and saddle points, in positions where experience has

shown that there will be strong enough winds to push the fog through the mesh of the collectors. The sites were also chosen to reflect a range of altitudes and

exposures. The final consideration in site selection was the ultimate point of use of the water. Table 1 gives the site details.

Table 1. Locations of Standard Fog Collectors in the Hajja Governorate, Yemen.

Area name	Average (L m ⁻² day ⁻¹)	SFC Number	Location UTM (WGS 72)	Orientation	Elevation
Schiraqi	0.34	1	352061 - 1729727	180	2260
Schiraqi	0.32	2	352061 - 1729727	270	2260
Schiraqi	0.61	3	352530 - 1730131	170	2450
Schiraqi	0.25	4	352530 - 1730131	270	2450
Schiraqi	0.49	5	352662 - 1730058	240	2450
Schiraqi	0.30	6	352887 - 1730132	180	2450
Schiraqi	0.33	7	352312 - 1729695	190	2300
Mabyan	4.49	8	346743 - 1739771	230	2020
Mabyan	4.54	9	346622 - 1739871	215	2030
Mabyan	2.92	13	347000 - 1739300	270	2000
Mabyan	0.93	10	347416 - 1737470	200	1650
Hajja City (Antenna)	0.98	11	350366 - 1735330	225	1820
Hajja City (MOA)	0.36	12	350114 - 1734950	180	1750
Humlan	0.77	14	351331 - 1733100	230	1775
Humlan	0.52	16	351420 - 1732770	270	1835
Humlan	0.71	15	351520 - 1732080	250	1890
Aschmur	0.05	17	366230 - 1735710	270	2840
Aschmur	0.04	18	366230 - 1735710	180	2840
Aschmur	0.06	19	366230 - 1735710	0	2840
Maswar Bait Sheim	0.05	20	357050 - 1728100	180	2640
Maswar Bait Sheim	0.02	21	357050 - 1728100	250	2640
Maswar Bait Sheim	0.02	22	357220 - 1728100	0	2660
Maswar Bait Saad Salah	1.12	23	355000 - 1727600	0	2440
Maswar Bait Saad Salah	2.08	24	355000 - 1727600	270	2440
Maswar Bait Saad Salah	0.88	25	355000 - 1727350	180	2485
Maswar Bait Saad Salah	1.42	26	355000 - 1727350	270	2485

3. RESULTS OF THE EVALUATION

The field data quantified the fog water collection potential in northern Yemen. The rates are very good, especially SFCs 9, 8, 13, 24, 26 and 23 with averages above 1 liter a day, during the dry season. The best sites, SFC#9 and SFC#8, averaged 4.5 L m⁻² day⁻¹. The collection rates are highest for sites between elevations of approximately 2,000 and 2,500 m above sea level in the Mabyan and Maswar districts. This range of altitudes was used as a starting point to continue testing fog collection in Yemen, since many villages are located at these altitudes. West winds are the most productive. They generate 80 % of the total fog collection. This humid air comes from the Red

Sea and Mabijan is the first mountain range encountered on the way inland. In examining the data site by site, sites 8 and 9, with the best collection rates, were well exposed to winds coming from the west up a major valley. Site 13 was in the same area but had lower collection rates as the exposure to the west winds was not as good. The two sites in Hajja city (11 and 12) did not produce high enough collection rates to justify the construction of LFCs at this time. An examination of the amount of fog water collected as a function of windspeed, shows that the fog is normally present with low wind speeds. Almost 50% of the collection occurred when the wind speed was in interval 2 of the Beaufort wind scale. No meteorological station was available at the

sites and all wind speeds were estimated by the observers recording the daily amounts of water collected.

4. THE OPERATIONAL PROJECT

The construction phase of the operational project took place in January 2004. The Mabijan area, about a 30 minute drive from the city of Hajja, was chosen

as the site for the large fog collectors (LFCs). A total of 25 were built in areas near a number of small settlements. The area was an exposed, rocky ridge line with poor soils and limited water resources through the winter.

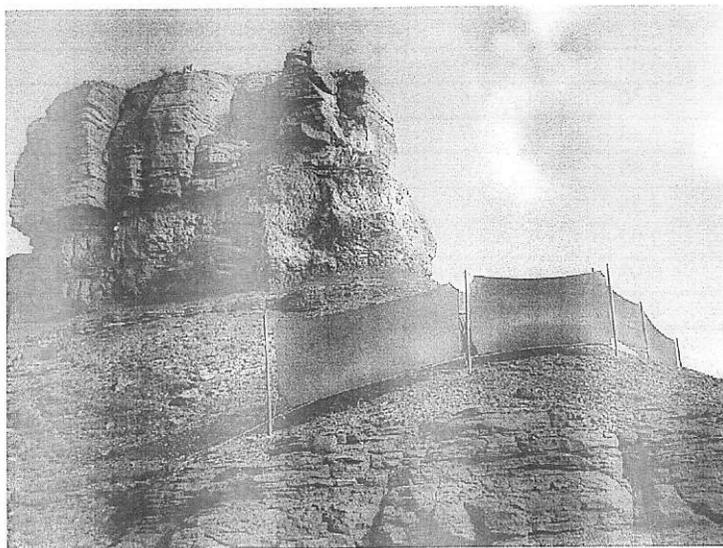


Figure 1. The large fog collectors at Shamsan, Yemen.

In virtually all other locations where LFCs have been constructed, the posts were made of local wood, e.g. eucalyptus, bamboo. However, long wooden posts are difficult to come by and very expensive in Yemen. For these reasons, the posts for this project were made of four-inch diameter water pipe or similar sized iron I-beam channel. This resulted in a few modifications to the standard construction techniques but fundamentally the LFCs are as at other locations. The construction was under the direction of a FogQuest staff member who worked closely with staff of the NGO, International Community Services – Yemen, and the workers from the local villages. The mesh collecting surface is 40 m² for each LFC and the mesh panel can be raised or lowered using pulleys. The posts were anchored in most cases using steel cables attached to large rocks buried about one meter underground. In some cases the anchor cables went directly to large surface rocks. The total collecting surface was 1000 m². The LFCs

were installed in a number of areas to service several small communities. The distance the water travelled in the pipes was short, not exceeding about 100 m. Based on the SFC measurements the previous winter, the total LFC array should produce approximately 4500 liters of water per day during the dry winter period. Water was being produced immediately after installation of the LFCs and was taken first to 1 m³ tanks where clean water could be withdrawn. ICS, based in Hajja, continues to work with the communities on acceptance of the novel water supply and on several maintenance issues that have arisen. Because of the dry soil, a number of anchors had worked loose and as a result were modified. In addition, winds during the summer of 2004 were extremely strong at the sites, resulting in significant damage. This may be related in part to a non-standard mesh that was used. These issues continue to be worked on to come up with a solid working solution for the conditions specific to these sites.

5. CONCLUSIONS

The results show that the fog collectors have produced the highest water outputs in the Mabijan district of Yemen. Winds from the west are the most productive. This humid air comes from the Red Sea and Mabijan is on the first mountain range encountered as the wind moves inland. Sites 8 and 9, with the best collection rates, were well exposed to winds coming up a major valley from the west. Water produced by the LFCs can be used directly by individual families in small 1 m³ containers, or can be stored in large rainwater cisterns, which are empty in the winter due to a lack of rainfall runoff. Previous studies (Schemenauer and Cereceda, 1992; Eckardt and Schemenauer, 1998) have shown that fog water is suitable as drinking water. The fog collection sites in Mabijan produce an average of 180 L of water per day per large collector, which is enough water to sustain a family of seven people. The LFCs have been in place for six months at the time of writing and issues have arisen with regard to the best construction techniques for this rocky, mountain location. The mesh used was sourced in Saudi Arabia and had a 45 to 50% shade coefficient rather than the 35% of the Chilean Raschel that is normally used. This may have led to increased wind loads on the fog collectors. One or more meteorological stations need to be installed at Mabijan to quantify the strong wind conditions experienced during the summer when rain occurs. Also, work needs to continue on increasing the participation of the communities in the operation, maintenance and future of the project. In terms of more widespread application in the region, all the ridges and mountain chains above 2.000 m, from the north (Saudi Arabia) to the south (Aden), would potentially be good productive sites and should be evaluated for their fog collection potential.

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