Testing Fog Collectors in the Namib Desert

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ABSTRACT

Over the past eight years the Gobabeb Training & Research Centre has been conducting tests with various fog-collecting appliances. After the initial conclusion that fog is, indeed, a viable supplementary source of potable water in the Namib Desert, tests have been conducted in order to further increase the efficiency and durability of fog collectors in prevailing conditions. While various designs and materials of large 50-m^2 fog screens were tested for durability in sand storms, a range of other tests concentrated on the materials themselves, their surface characteristics, as well as the addition of effects that enhance fog deposition or condensation. We also outline how fog collectors are already being used, e.g. to supply a small-scale evaporative cooler with water. When these tests have culminated, there should be considerable potential for the application of fog water in the western Namib Desert.

1. INTRODUCTION

Reliable and permanent fresh water sources other then fog are scarce in the Namib Desert. The Central Namib Desert receives <22 mm of rain and 30-380 l.m^{-2} of fog per year (Henschel *et al.*, 1998). Fog is a more frequent and reliable source of surface water compared to rainfall. This makes fog a water source that can be harnessed for human consumption. Fog has previously been identified as a feasible alternative source of water that could supplement existing traditional sources (Shanyengana, 2002).

However, the frequent occurrence of destructive sand storms (with wind speeds ranging up to 24 – 32 m.s^{-1}) has been identified as one of the major constraints for the successful implementation of the fog harvesting systems in Namibia using established techniques (Shanyengana, 2002). Every winter, East Winds (also called Bergwind or Föhn) reach storm strengths, varying in direction from SE to NNE, and these storm forces impose high mechanical stress on the relatively fragile structures of cost-effective fog collectors (Henschel *et al.*, 1998).

Since 1996, various tests were carried out in the Namib Desert aimed at improving the efficiency and durability of fog collectors in prevailing climatic conditions. Here we report our tests with passive collectors. We should point out that we have also tested active collectors that apply air movement to enhance deposition or chill to enhance condensation (Shanyengana 2002).

2. NAMIB FOG

Fog in the Namib Desert is both spatially and seasonally variable. Since 1996 the Gobabeb Training and Research Centre have used Standard Fog Collectors to monitor fog deposition in the Central Namib Desert (Henschel *et al.*, 1998; Mtuleni *et al.*, 1998). The results indicated a strong seasonal variation in fog frequency, with peak inland fog season being from August to January and the low season being February to July (Henschel *et al.*, 1998). Lancaster *et al.* (1984) indicated that in the 60-km wide fog belt there is a decrease in the fog day frequency from the coast inland, while fog precipitation increases in the zone 20-30 km inland, and decreases beyond. Wind plays a major role in the transportation of fog. The Namib has several kinds of fog, which includes advective, radiation, and frontal fog, as well as intercepted clouds or high fog (Seely & Henschel, 1998).

The Gobabeb Training and Research Centre tested the possibility of fog collection at various sites in the central Namib Desert. Fourteen standard fog collectors were placed at six sites near Topnaar villages along the lower Kuiseb River (Henschel *et al.*, 1998). The orientation of the SFCs was north. The sites were of various physical characteristics, altitude and distance from the sea. The study found that fog has a potential of providing potable water to villages in the Namib Desert, but this is only feasible at places located less than 50 km from the Atlantic Ocean (Henschel *et al.*, 1998).

3. TESTS ON VARIOUS MATERIALS

3.1 Raschel mesh

Raschel mesh is used in standard fog collectors (SFC) and was the material used for the large-scale fog collection schemes in Chile (Cereceda *et al.*, 1992). This particular material is not readily available in Africa, and it yielded less collected fog than some other materials tested. Furthermore, it has rather limited durability in Namib conditions (Shanyengana *et al.*, 2003). We therefore tested some alternative materials.

3.2 Aluminet

Fog collection tests were carried out with polymeric greenhouse shade nets to investigate the feasibility of using these materials in fog water collection as an alternative to the Raschel mesh (Shanyengana *et al.*, 2003). Outdoor and indoor Aluminet greenhouse shade nets of varying percent shade coefficient were used to make the fog collectors. The indoor weave is similar to that of the Raschel mesh that is used in SFCs and proved to be more suitable for fog collection than the outdoor type. Results from collectors made from the indoor weave mesh of varying percent shade coefficient indicated that the 40% shade coefficient is more appropriate for fog collection than the 60% and 90% mesh (Shanyengana *et al.*, 2003). The 40% mesh collects 10-50% more fog water than Raschel mesh. Unlike Raschel mesh, Aluminet also collects dew besides fog (Shanyengana *et al.*, 2003). Aluminet also appears to be more resilient to stretching by wind forces. We are currently testing this material for durability in large collectors.

3.3 Testing other types of mesh

In efforts to combine fog-collecting properties of materials with the requirement of strength to endure sand storms, we tested other kinds of mesh. Three-dimensional cubically-woven mesh (Kimre) appeared to be storm resistant, but yielded only 44-93% of the quantity of fog that Rashel mesh did.

Currently we are testing the fog collection efficiency of PTFE material (Lenzing Plastics, Lenzing, Austria). This material is highly stretch-resistant and it is claimed that it is resistant against weathering by ultraviolet or extreme heat, characteristic of the Namib Desert. It is hydrophobic and antiadhesive, properties identified as desirable for fog harvesting (Shanyengana, 2002).

3.4 Alternative collecting methods

Based on physical, chemical and biological principles identified in previous research (Shanyengana, 2002; Shanyengana *et al.*, 2003; Henschel & Seely, 2004), we are continuing our investigations with alternative methods to collect fog, dew or water vapour.

4. LARGE FOG COLLECTORS

4.1 Chile Prototype

Since 1998, the Gobabeb Training and Research Centre conducted experiments on large fog collectors (Henschel *et al.*, 1998; Mtuleni *et al.*, 1998; Seely & Henschel, 2000), starting with the prototype developed in Chile using Raschel mesh (Cereceda *et al.*, 1992, 1996). This has been tested and is being used for fog water supply systems in Chile and elsewhere in the world. It soon turned out that the Chile prototype did not endure Namib wind storms very well (Table 1).

4.2 Planning Adaptations to Namib Conditions

Several solutions were considered:

- Insert weak links into the net supports, which would break before the net is damaged. This would be impractical for water collection schemes in the Namib due to the frequency of storms every year and consequent frequent need for repairs of collectors.
- A system manager in a rural village pulls down nets before storms. There would be a risk of overlooking an unexpected storm event. The opposite, of pulling up the nets when fog approaches would also be problematic because of the unpredictability of fog on a daily basis, and its onset late at night.
- Build frames or nets to be flexible and so that they yield in strong storms. Several kinds of designs were made, but none were tested. The additional complexity departs from the premise of keeping this technology simple and easy to manage. Furthermore, sandy conditions would make movable parts vulnerable to mechanical disruption.
- Increase structural support to the net to reduce stress on the material. Our tests focused on this approach of adapting the Chile prototype.

Table 1: Tests with large fog collectors conducted by the Gobabeb Centre over the course of the years. Modifications were cumulative unless stated otherwise.

YEAR	STRUCTURAL ADAPTATION	FIXING OF NET	RATIONALE	DAMAGE
1998	48 m^2 net (Cereceda et al., 1996)	Raschel net fixed as in prototype, no additional support	proven track record	stretching of material allows flapping, net tears near fix points
1999	Subdivide frame into two 24 m^2 screens	additional pole in centre of net	less area between fix points	less severe, but same symptoms
2000	Support with steel ropes on each side	guy wires limit ability of net to move	confinement reduces stretching	additional friction weakens fog net and it tears along lines
2001a	Subdivide frame into four 12 m^2 screens and support with wire diamond mesh	net can only be tied to backing at edges	wind presses net onto resilient backing	numerous friction points weaken fog net over entire area esp. edges
2001b	Replace diamond mesh with reinforcing steel	tie net onto backing at many points	many fix points limit friction, spread stresses	stress still concentrated at edges, where net tears
2002	Fix reinforcing steel to frame of steel pipes	stitch entire net to stable backing, stitch lines 50 cm apart	stabilize edges of net with rigid metal frame	no damage but potential exists because there is no way to take up the slack
2004	Steel pipe supports mounted only along lateral edges of net	Aluminet net, tension-adjusting bolts at multiple points	take up minor slack whenever and wherever it arises	already survived several storms without damage

4.3 Increasing Structural Support to the Net

Tests in successive years built upon previous results. On the whole, the adaptations achieved a reduction of the stresses that would be experienced by the net material on a small scale by distributing stress points to many points. This was achieved by the addition of structural supports across the length and width of the fog net through:

- reducing the effective area of the net by subdivision of the frame (Table 1, 1999 and 2001);
- adding backing to the net to absorb the wind force;
- strengthening net edges with lateral supports whose tension can be adjusted at multiple points interconnected with the frame;
- using strong material that is also superior in the quantity of fog and dew collected per unit area of net (Aluminet instead of Raschel).

This design appears to be promising in terms of durability and yield, but final results await further testing in sand storms.

The large fog collector of Aluminet at Gobabeb is connected to an evaporative cooler room for fresh produce at the Gobabeb conference hall. Thereby we are demonstrating that cooling can be achieved without the use of electrical energy nor ground water. This fits into the Gobabeb Centre's programme concerning Sutainable Development Technology.

5. CONCLUSION

Studies carried out in the central Namib Desert indicate that fog has the potential of yielding potable drinking water. The main challenge is the design and use of effective fog collectors that are both durable and affordable. The issue of affordability is of utmost importance, as the end users of fog water will be poor rural communities. This was the premise for our successive tests to develop practical fog collectors in support of sustainable development in rural Namibia.

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