A Proposed Standard Fog Collector for Use in High-Elevation Regions

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ABSTRACT

The collection of fog droplets by vegetation is an important wet deposition process. It can, in fact, dominate the chemical and hydrological input to certain high elevation watersheds. However, measurements of fog deposition are rarely made and, where they do exist, comparisons of deposition rates in different locations have been hampered by the use of innumerable types of collection devices. A simple, inexpensive, 1-m^2 fog collector that can produce measurements of the deposition of fog water to a vertical surface is described here. The collector has been used successfully in five countries to investigate the variation of fog deposition in complex terrain and to estimate the deposition to trees and to much larger fog collectors. It is proposed that it be employed widely as a standard to quantify the importance of fog deposition to forested high elevation areas and to measure the potential collection rates in denuded or desert mountain ranges.

The standard fog collector costs about the same as a rain gauge ($100 U.S.) to construct and can be used with a variety of recording devices. It is a flat panel made of a durable polypropylene mesh and mounted with its base 2 m above ground. Fog collection rates are typically 1–10 L m^{-2} of vertical collecting surface per day but can reach values of 30–40 L m^{-2} day^{-1}. The presence of drizzle or light rain with the fog, coupled with 10 m s^{-1} winds, has produced collection rates as high as 300 L m^{-2} day^{-1}. If a standard fog collector is installed at a site with wind speed measurements and a conventional rain gauge, a reasonable estimate can be made of the proportions of fog and rain being deposited on the vertical mesh panel. This information is fundamental to the understanding of acidic wet deposition at higher elevations and to comprehensive hydrological calculations in watersheds.

1. Introduction

Precipitation is normally considered as the only source of water for watersheds. Measurements of drizzle, rainfall, and snowfall, in several locations, are integrated to estimate the annual water input. This produces acceptable results in low-elevation watersheds or in denuded higher elevation sites, but in forested high-elevation areas that experience frequent episodes of fog as a result of the advection of clouds over the surface of the mountain, the consideration of precipitation alone may seriously underestimate the water input to the watershed. A number of summaries of fog collection experiments have been made (e.g., Kerfoot 1968; Stadtmüller 1987; Schemenauer and Cereceda 1991; Vong et al. 1991) that clearly show the importance of fog as a wet deposition pathway.

Despite the large number of measurements of fog collection by trees and other various types of collectors over the last century, it is almost impossible to quantitatively compare the collection rates. There are two reasons for this. The first is that in many experiments the investigators neglected to determine the amount of precipitation that was also entering the collector. This can be very significant in windy high-elevation sites and has been discussed, for example, by Fourcade (1942) in his critique of fog collection experiments near the turn of the century in South Africa. The second major reason for the lack of quantitative comparisons is the wide range of artificial collection devices that have been used. Schemenauer et al. (1988) illustrate, for example, some of the devices that were used in Chile over a 30-yr period. Many other devices were used at earlier times in other countries: Marloth (1905), for example, in South Africa used reed bundles on top of a standard rain gauge. These, and other examples, confirmed what had been observed in forests in many experiments, that is, a vertical collecting surface (a tree) can produce additional water on the forest floor on both days with rain and fog, and on days with fog alone. Unfortunately, for the reasons stated above, it is impossible to make quantitative use of the data generated in most of these projects.

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Rubner (1932) wrote, "A simple reliable measuring instrument is still lacking for horizontal precipitation;[1] the same holds true for a uniform unit for this type of precipitation. Such a unit is required so that the data obtained are comparable with each other." These statements remain true today. Rubner went on to use a fog meter, on the advice of Dr. Alt of Dresden, consisting of 1-m-long, 6-mm-diameter, glass staffs set above a rain gauge. Later, aluminum rods were used. Tabata et al. (1953), as early as 1948, used a cylinder of 15-cm-long vertical wires made from 0.12-mm-diameter enameled copper wire. Perhaps the most widely employed fog collector was the Hohenpeissenberg collector (Grunow 1952, 1960), which was used in many countries in the 1950s and 1960s. It consisted of a small vertical cylinder of metallic mesh mounted over the top of a conventional 10-cm-diameter rain gauge. The cylinder was 20 cm high and had a cross-sectional area of 200 cm^2. The wire diameter in the mesh was 0.25 mm and the mesh size 1.5 mm. Some problems with the collector were its small size, lack of representativeness with respect to vegetation, the storage of water in the small openings of the mesh, and the ability of precipitation to enter directly into the rain gauge portion, which confounds the measurement of fog deposition. In addition, the calculation of "fog precipitation" by simply subtracting the amount of rain in a standard rain gauge (Grunow 1963) from that in the Hohenpeissenberg collector, led to erroneous results anytime there was wind present. A fog collector developed for use in Hawaii (e.g., Juvik and Ekern 1978) also consisted of a cylindrical wire screen over a rain gauge, but with the addition of louvers on the screen. In their wind conditions, the authors concluded that the collection of wind-driven rain was not a problem.

In recent years, two separate issues have given rise to the need for distinct fog collectors. The first was the need to study acidic wet deposition from high elevation fogs in the mountains of eastern North America and in Europe. This is a major pathway for the entry of pollutants into soils and vegetation. Mohnen and Kadlecek (1989) have reviewed the principles of cloud/fog collector design. The most widely used collectors are based on a design of Falconer and Falconer (1980). They developed a cylindrical, 1-m-high, Teflon string collector, which could be very carefully cleaned prior to use. Slightly modified versions of this Atmospheric Sciences Research Center (ASRC) collector have been used successfully throughout eastern North America (e.g., Saxena and Lin 1990; Mohnen and Vong 1993) and other parts of the world (e.g., Post et al. 1991; Schemenauer and Cereceda 1992a,b) to collect fog samples for chemical analysis. This collector produces of the order of 100 mL of water per hour and has been shown to have a collection rate that is well correlated to that of coniferous tree tops (Joslin et al. 1990). Its disadvantages are that it is expensive, approximately $1,200 U.S. and relatively difficult to manufacture. Active fog collectors, where a fan pulls air past collecting filaments, have also been widely used to collect fog samples for chemical analysis (e.g., Daube et al. 1987). These also are expensive and require a power source.

The second requirement for a fog collector comes from the long desire to use fog as a water supply in Chile and elsewhere (e.g., Schemenauer et al. 1987), as well as the development of projects designed to extract large quantities of water from high-elevation fogs for domestic and agricultural purposes in developing countries (Cereceda et al. 1992). Before large fog collectors are installed, an evaluation must be made of the prospective site. This has been undertaken in a number of countries using a simple inexpensive fog collector developed for the purpose. The construction and use of this collector are described below.

2. Description of the standard fog collector

a. Structure

The proposed standard fog collector (SFC) (Fig. 1) consists of a frame that measures 1.0 m × 1.0 m on

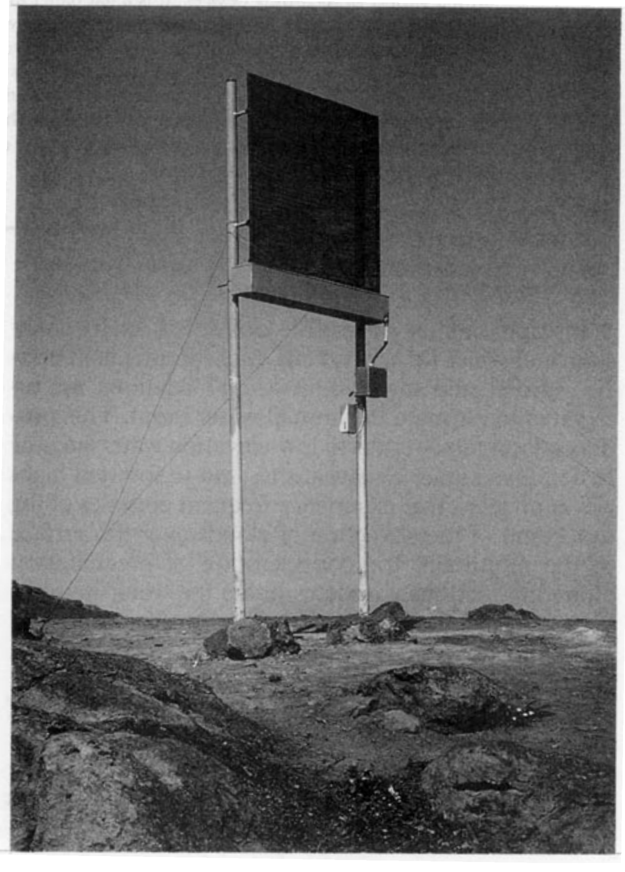

FIG. 1. Proposed standard fog collector on the ridge at Cerro Orara, Peru (430 m). The panel is 1 m × 1 m and the base of the panel frame is 2 m above ground.

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[1] Fog (authors' note).

the inside (Fig. 2). The frame itself is 1 cm in diameter, or width, and should be made of metal for rigidity. It can be galvanized, painted, or made of aluminum to prevent rusting. In open areas, the frame is supported with its base 2 m above the ground. Standardizing the height of the frame above the ground is important because fog collection will vary with height. Immediately below the frame is a collection trough for the fog water. The trough can be square, semicircular, or triangular in cross section, with an opening at the top that is 1.04 m long and 15 cm wide. The depth of the trough should be 10 cm or less. The windward side of the trough should be 2 cm in front of the frame and at the same height as the bottom edge of the frame. The backside of the trough should extend 12 cm behind the frame to collect any drops that may come off the frame at an angle in high winds. This design will allow the trough to collect all of the fog water and drizzle that impacts on the SFC, without having a substantial trough area in front that can act as a direct collector of drizzle and rain. If fog and strong winds are equally likely from the front and back of the mesh, then the trough can

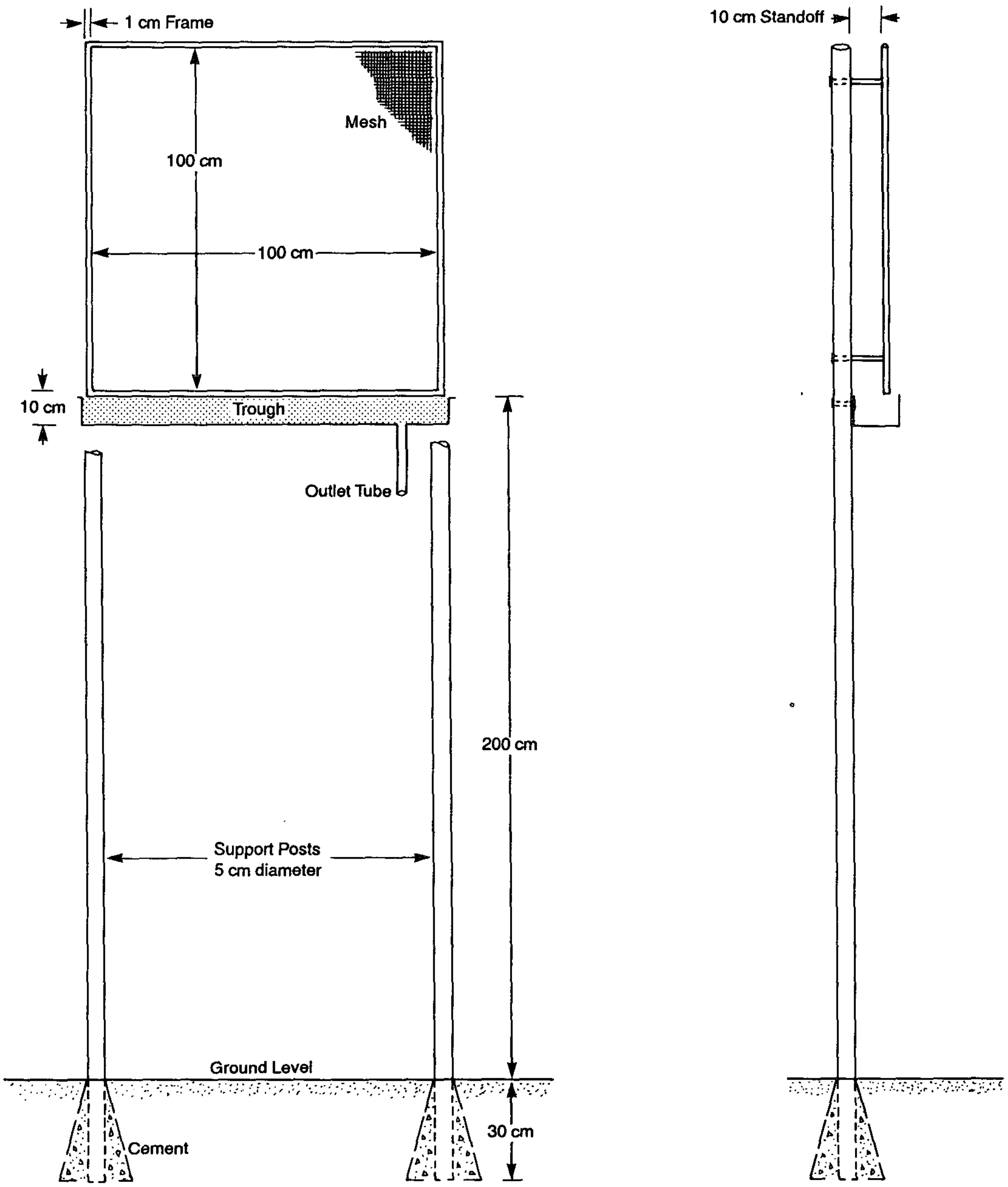

FIG. 2. Dimensions of the main components of the proposed standard fog collector.

be centered under the frame. This may lead to the desirability of correcting for precipitation (if present), which can fall directly into the trough.

The trough should have a slight slope to drain the water to one end where there is an opening with a connection to a plastic tube of 7–10-mm inside diameter. Smaller tubes should be avoided in order to prevent the tube from becoming plugged with sediment. In the simplest configuration, the tube takes the water to a closed plastic storage container of sufficient volume to allow for the storage and measurement of all the water collected during the sampling period. In a more sophisticated operation, the water collection rate is measured continuously.

The SFC can be supported in two ways. The preferred way is with two posts of approximately 5-cm diameter. The posts are centered 1.01 m apart. The vertical sections of the collector frame are bolted to the upright posts with a 12-cm space in between to allow room for the trough. The bases of the two posts should be set in concrete to a depth of 30–50 cm, or bolted to a concrete base, and the posts should be supported with two guy wires each. A somewhat cheaper construction is with one post centered behind the collector. In this case, great care has to be taken to ensure that the mesh does not flex and touch the post in high wind conditions. This will require a minimum mesh to post spacing of 12 cm. When the SFC is not being used in open areas, for example at the top of a forest canopy, specialized support structures will have to be designed.

An innovative adaptation of a single-post fog collector is the omnidirectional collector, which employs bearings and a wind vane to keep the panel of the SFC normal to the wind. By the use of eight receiving containers, the wind direction producing the maximum fog deposition can be determined. It has been seen that functional omnidirectional collectors can be constructed in local machine shops in developing countries, and that they are valuable in locations with highly variable wind directions. The quantifying of fog deposition by octants is information that cannot be obtained by a fixed SFC or a cylindrical collector.

b. The mesh

The mesh should be of the same material in all of the standard fog collectors to enable direct comparisons to be made between sites and subsites, and between locations in different countries. Even this simple change to a standardized mesh would be of great benefit to those doing research in this area. The material chosen for use by the authors is 35% shade coefficient polypropylene mesh, which is used in a double layer as shown in Fig. 3. It is manufactured in Chile by Coresa (see the Appendix). A similar material is manufactured by Marienberg S.A. in Chile and by Tildenet Ltd. in the United Kingdom. For six years, the Coresa material has been used for the large fog collectors at El Tofo, Chile, and its collection efficiency has been studied using laser-optical probes in front of and behind the mesh (Schemenauer and Joe 1989). The actual area covered by the fibers has been calculated to be 40%, but this will depend on the degree to which the mesh is stretched. The fiber width is 0.5–1.5 mm for the same reason but is typically 1 mm wide. The mesh is woven in a triangular pattern and has a spacing between the horizontal lines in the mesh of 1.3 cm. The mesh is inexpensive, UV protected, and has a lifetime of about ten years.

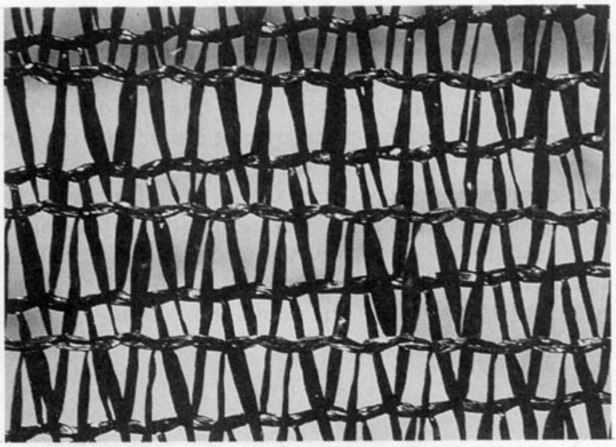

FIG. 3. A double layer of Coresa 35% shade coefficient, polypropylene, Raschel mesh. A double layer of mesh is used in the standard fog collectors. The fiber is about 1 mm wide.

The mesh is placed on the standard collector frame in a double layer (Fig. 3), and thus, slightly more than 2 m^2 of mesh is required for each collector. A section of mesh approximately 1.15 m × 2.15 m is appropriate. The mesh is pulled tightly over the frame with the support lines of the mesh oriented horizontally and the fibers at an angle to the vertical, forming a triangular pattern. The mesh is then sown with polypropylene line on the inside of the frame. Alternatively, UV protected plastic cable ties can be used to secure the mesh to the frame. The two layers of mesh should be touching and should be as taut in the frame as is practical without deforming the mesh. The extra mesh is then trimmed off the outside of the frame.

The double layer of mesh covers approximately 60% of the surface area of the collector. This leaves about 40% of the area open for the wind to pass through. The choice of a mesh is a balance between having a fiber of a width that will have a high collection efficiency for the droplet sizes and wind speeds of interest, yet, at the same time, covering a large enough percentage of the surface area to generate sufficient water for measurement purposes (Schemenauer and Joe 1989). If too high a percentage of the surface area is covered by the mesh, the collector begins to act as a solid wall and the wind-carried fog droplets will pass around the collector. Other practical considerations are also important: the mesh must be inexpensive (in this case less than \$0.25 U.S. per square meter); it must be durable in wind, sun, wet conditions, and strong winds; it also should drain water quickly. The construction of one standard fog collector will cost from \$50 to \$150 U.S. depending on the materials used and the local labor costs.

c. Measurement errors

The efficiency with which a three-dimensional mesh collects fog droplets is not well understood (Schemenauer and Joe 1989), particularly when it is used in strong winds and takes on a series of concave shapes dictated by the nature of the supporting frame and cables. The actual collection efficiency of a 1-mm-wide ribbon, such as is used in the SFC, varies from 70% to 95% for wind speeds of 2–8 m s^{-1} and droplet diameters of 11–15 μm (Langmuir and Blodgett 1946). Collection efficiencies are better for higher wind speeds and larger droplets. The measured collection efficiency of the double layer of mesh, in the center of the large fog collectors, is 66%, which reflects the approximate percentage coverage of the mesh in the collector (Schemenauer and Joe 1989).

The collector is designed with a specified inside dimension of 1.00 m × 1.00 m. The frames will vary somewhat depending on construction techniques but should have a width of about 1 cm. This adds 400 cm^2 of collecting surface, since water dripping from the frame also enters the trough. This is 4% of the collecting area and can be corrected for or allowed to be a small systematic error in the measurement. It is recommended that the frame correction be made to the data to allow for slight differences in construction techniques.

If an event occurs with drizzle or rain, the mesh will collect almost all of the precipitation that would have fallen into the rain shadow area behind the collector (Schemenauer and Cereceda 1992c). The collected volume of water will contain both fog and precipitation in proportions that can be established, if there are supporting wind speed and conventional rain gauge data. In some locations, such as the coasts of Peru and northern Chile, the amount of precipitation is negligible (less than 10 mm yr^{-1}), and the water collected on the vertical mesh can be assumed to be from fog with a minimal error. In other locations, the water will have to be assumed to be from both fog and precipitation unless the inputs can be decoupled using supporting data. This is not necessarily a detriment since it will still represent what both trees and large collectors will receive. The collection must, however, not be stated as being from fog alone in these cases. It is possible for precipitation to fall directly into the 1.02 m × 0.02 m opening on the front of the trough and not pass through the mesh. But, even in gentle winds, this will only collect 1% of the precipitation that the mesh collects and the effect will decrease as the wind speed increases.

The height of the collector base was chosen to be as high as would be practical for the purposes of servicing it. The base is 2 m above ground. A lower height will produce less collection because the wind speeds are lower. A higher height will produce a higher collection rate; though, as will be seen below, the SFC produces collection values in good agreement with those of the large collector, which has its mesh between 2 and 6 m above ground. In special circumstances, for example, in a forested area, the SFC could also be installed at or above canopy top.

The SFC is a flat surface installed perpendicular to the prevailing wind direction, during fog events, at the site. A change in wind direction will mean that the fog approaches the collector at an angle and the collection efficiency will change. For the purposes of measuring the frequency of fog events, or predicting what large fog collectors will produce, this is acceptable. For other purposes, such as predicting what a tree will collect, this may not be an optimum choice but it proves to be acceptable (see section 6). The SFC is a flat vertical surface because of its low cost, simplicity of construction, and its ability to mimic the collection of the large flat fog collectors. The same mesh could have been used in a cylindrical collector exposed to all directions, but with the loss of the advantages noted above and the added complication of having to dispose of drizzle and rain falling on its upper surface. In areas where it is not known from which direction the fog comes, it is recommended that an omnidirectional collector, with a wind vane, be used initially to determine the predominant wind direction during fog events. The SFC can then be installed facing that direction.

3. Units of measurement

As Rubner (1932) correctly pointed out, it is important to have a commonly used unit of measurement. As one reads the literature of the last century of fog measurements, there is endless confusion as to what was actually collected, since the data are often expressed in terms of a value converted to a depth in a rain gauge used in a particular country at that time. This depth will depend on the configuration and size of the vertical portion of the collector and the size of the rain gauge opening. Results were sometimes expressed in terms of the depth of water on the wires of the collector or on the curved surface area of the collector. Ambiguity in terminology often led to confusion as to what might have been collected on the vertical cross-sectional area of the collector.

The output of the standard fog collector is liters of water. Since the surface area is 1 m^2, this gives a collection in liters per square meter. Normally, one is interested in daily values and, therefore, units of liters per square meter per day are recommended. Other time periods can also be specified while still preserving the core information of the number of liters of water that were collected. This has proven to be a useful unit for the calculation of both deposition values to forests and for calculating the output of large collectors. One liter per square meter is equivalent to a depth of water of 1 mm over the 1 m^2 of the collector.

4. Data loggers, tipping buckets, and anemometers

When the standard fog collector is equipped solely with a container to store the collected water, only the most basic of information is obtained, and the time resolution will depend on the frequency with which the observer can visit the site. This is normally once each day or once each week in remote areas. Thus one might know the number of liters of water per square meter collected each week, but not, for example, the difference between daytime and nighttime collection.

In order to obtain more detailed information to better understand the fog water production characteristics at the sites, a sophisticated, but comparatively inexpensive (<\$1000 U.S.) package was assembled to collect and record the field data. It consists of wind speed and direction sensors, a tipping bucket, and a data logger with three or four channels. This instrumentation was used to obtain the data presented in section 5.

The tipping bucket (Pronamic 100.051) receives the water from the standard collector and produces an electrical pulse for each 5 cm^3 of water. The tipping buckets have been calibrated and are useful up to very high collection rates (5–10 L h^{-1}). For higher collection rates, larger tipping buckets can be used. The anemometer (manufactured by Davis Instruments Co.) used produces two outputs, one for wind speed and the other for wind direction. The anemometer has been calibrated against the much more expensive model 013A MET-ONE anemometer of a Campbell Scientific Inc. weather station and found to perform well. The only qualification is that it is only usable in winds above 1.2 m s^{-1}, which in practice does not present problems. Another type of inexpensive anemometer, with a different output, is available from Peet Brothers Co. Inc. All of the data were recorded on a three-channel data logger (Dachris Inc.). The data logger is in a weatherproof box, which can be attached to one of the support posts of the SFC. The three inputs are sampled every 5 s and the data are combined to form 5-min, 15-min, or 1-h averages, whichever the operator chooses. The memory is sufficient for a 2–4-week period depending on the averaging time. The data are removed from the memory on a small RAM card (made by Fujitsu). Presently each RAM card can hold the data from eight data loggers. The card is then placed in a RAM card reader (available from Adtron Corp.) to transfer the data to a computer. Once in the computer, the data can be manipulated with conventional software.

5. The use of the standard fog collector

The primary use to date of the SFC has been to examine the different fog collection rates on a topographic feature such as a ridgeline. The applications are in desert reforestation and in the siting of large fog collectors. The collection rates depend on the local fog frequency, fog liquid water content, and wind speed. The liquid water content may in turn be related to droplet size, which will affect collection efficiency. Figure 4a shows the variation in collection induced by the microtopography at two subsites, separated by 200 m in the horizontal, on the El Tofo, Chile, lower ridge (elevation 720 m). Figure 4b shows the wind speeds at the two collection subsites for the same periods. The anemometers were mounted on the SFCs, and the measurements were made 50 cm to one side. Clearly, the lower collection at the second subsite is associated with lower wind speeds. In a similar manner, the variation in collection rate with height above ground has been investigated in several countries using a series of SFCs on a 10-m tower.

6. Collection by trees

Joslin et al. (1990) have shown that the collection of fog by an ASRC collector is well correlated with the collection by artificial foliage and natural coniferous tree tops. A very similar fog collector (AES/ASRC) has been used in Canada since 1985 (Schemenauer 1986) at mountain sites in Quebec. The AES/ASRC collector is 25.3 cm in diameter and collects fog droplets on 370 vertical Teflon fibers, each 0.5 mm in diameter and 48.5 cm long. A comparison of fog collection rates by the SFC and the AES/ASRC collector at an altitude of 845 m on Roundtop Mountain in Quebec is shown in Fig. 5. The SFC was facing west, which is the prevailing wind direction, and the wind speed over the period varied, with few exceptions, between 250° and 300°. The period of almost three days shown in Fig. 5 is part of an extended three month comparison period. The SFC collects more total water because the collection surface is greater. It also collects more water per square meter if the AES/ASRC collection is normalized per square meter of cylindrical surface, but less water per square meter if the vertical cross section is used. The narrower fibers in the AES/ASRC collector will have a better collection efficiency than those in the SFC, but the operation of a three-dimensional collector is much more complex than is collection on a single fiber. The outputs from the two collectors are highly correlated and the ability of both collectors to define the fog periods is clear. The correlation coefficient r for the volumes of water collected by the two collectors in this period is 0.84 ($p < 0.0001$), r^2 is 0.71. This evidence for a strong linear relationship between the SFC and the AES/ASRC collector exists for periods of fog, for periods with precipitation, and for periods of mixed fog and precipitation. Therefore, the conclu-

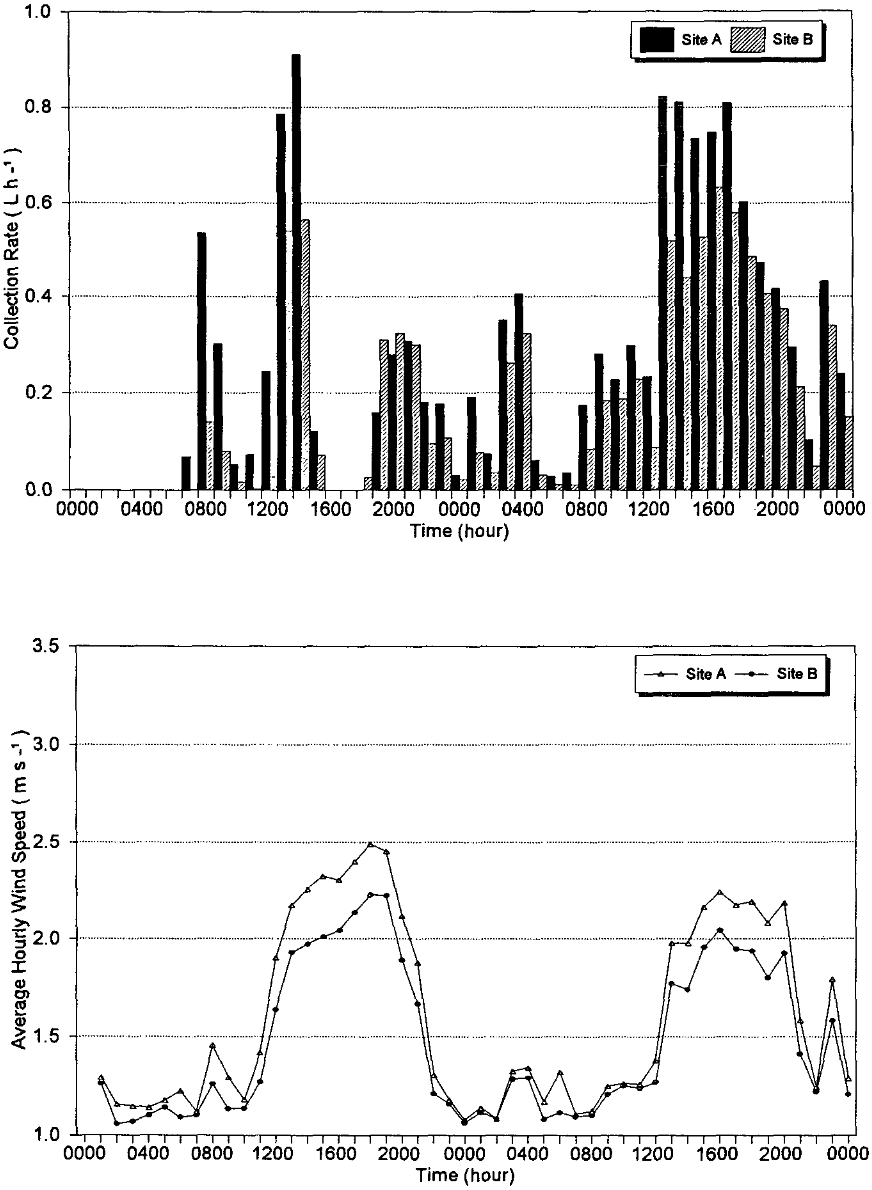

FIG. 4. (a) A comparison of the fog collection rates at two locations on the lower ridge at El Tofo, Chile (720 m). (b) The wind speeds at the same two locations.

sion of Joslin et al. (1990), that the ASRC collector should be a good surrogate collector for spruce tree crowns, should apply to the SFC as well.

Schemenauer and Cereceda (1992c) have looked at the mechanisms by which trees collect fog and precipitation. They also reviewed the rates at which trees collect fog and drizzle as measured by a number of authors. The rates, normalized to a vertical cross section, were quite variable, 6–70 L m^{-2} day^{-1}, depending on the conditions and the duration of the experiment. Where there are comparable measurements with a SFC, the collection rates are similar. For example, at Masroob, Oman, an olive tree (*Olea europaea*) on a hilltop at 920 m collected an average of 70 L m^{-2} day^{-1} over 79 days in 1989 (Barros and Whitcombe 1989) and a SFC averaged 86 L m^{-2} day^{-1}. This is excellent agreement considering that there is some uncertainty in knowing the vertical cross section of the tree; some water may have evaporated from the tree during the rare dry periods, and some water dripping from the tree is known to have escaped the collection container. Work with other species of isolated trees has also suggested that the SFC can provide useful estimates of the collection rates of wind-driven fog and precipitation.

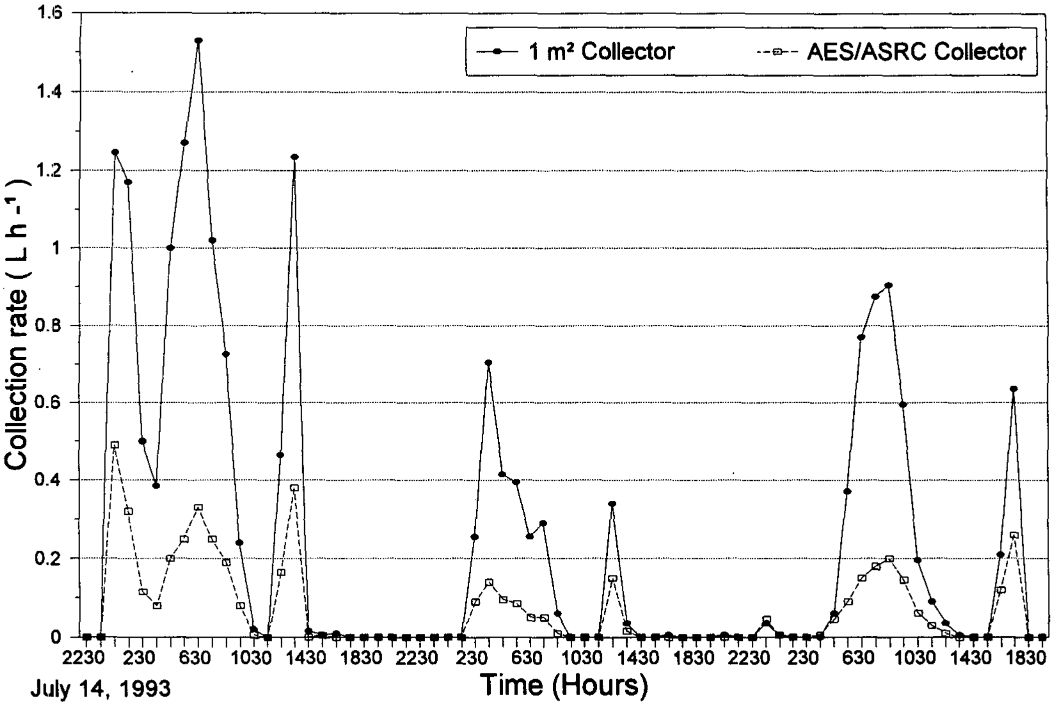

FIG. 5. A comparison of the fog collection rates as measured by a standard fog collector (SFC) and an AES/ASRC Teflon string collector. The data are for a 3-day period at a site (845 m) on Roundtop Mountain, Quebec.

7. Comparison to large collectors

At the El Tofo field site in Chile, large fog collectors (48 m^2 each) have been installed since late 1987. Table 1 shows a comparison of the water collection rates from a 48-m^2 collector, an SFC located 5 m in front of the large collector, and a small 0.5 m × 0.5 m collector (0.25 m^2), with a base 1 m above the ground, which was used in previous fog studies (Schemenauer et al. 1987). It can be seen that the collection by the SFC and the 48-m^2 collector are in good agreement. There can be up to a 15% difference in a given hour, but the average collection, over 6.5 h, is in excellent agreement, 1.28 L m^{-2} h^{-1} for the 48-m^2 collector and 1.26 L m^{-2} h^{-1} for the 1-m^2 SFC. The smaller 0.25-m^2 collector produces less water per square meter because it is closer to the ground and because it has only a single layer of mesh. The data presented in Table 1 are for cases where only fog was present.

In 1989 (Schemenauer 1989), it was recommended that SFCs using double layers of locally available polypropylene mesh be used in the Dhofar region of the Sultanate of Oman to assess the importance of fog water to the water resources of the coastal mountains. Subsequently, a comparison (Barros and Whitcombe 1989) was made of the collection rate of an SFC and the collection rates of an 11-m^2 large collector, made of the same mesh. The mesh, in this case was made of 47% Tildenet from Britain that had the same collection rate (6.4 L m^{-2} day^{-1}) as a 50% Coresa mesh (0.9-cm horizontal line spacing) from Chile (6.3 L m^{-2} day^{-1}) and a linearly correlated output ($r = 0.96$, $p < 0.01$). The average output from the large collector was 6.0 L m^{-2} day^{-1}. In Oman, there was drizzle present with

TABLE 1. Comparison of collection rates for three fog collectors of different sizes at the El Tofo, Chile, site in 1992.

Time (min)	48 m^2 (L)	1 m^2 (L)	0.25 m^2 (L)	48 m^2 (L m^{-2} h^{-1})	1 m^2 (L m^{-2} h^{-1})	0.25 m^2 (L m^{-2} h^{-1})	Ratio 48:1
60	80	1.60	0.11				1.04
60	90	1.94	0.17	1.88	1.94	0.68	0.97
60	80	1.98	0.18	1.67	1.98	0.72	0.84
150	100	1.81	0.13	0.83	0.72	0.052	1.15
60	48	0.86	0.09	1.00	0.86	0.37	1.16
Mean				1.28	1.26	0.42	1.03

the fog, but again, the ability of the SFC to predict the output of the larger collector was very good.

The above experiment was repeated in Oman in 1990 at a different site (COWIconsult 1990). Over a period of one month, the 1-m^2 47% Tildenet averaged 6.7 L m^{-2} day^{-1} and the 50% Coresa, 8.0 L m^{-2} day^{-1}. The correlation coefficient for the outputs was 0.99. A different configuration of 50% Coresa was used in this year (1.5-cm spacing of horizontal lines) possibly resulting in improved collection. However, it is more likely that the SFC with 47% Tildenet was poorly located. The correlation coefficients for the output of the SFC (47% Tildenet) and the 16-, 32-, and 48-m^2 collectors, all with 47% Tildenet, were 0.96, 0.96, and 0.97, respectively. The output, though, of the SFC was lower in this case than from each of the larger collectors, by 25%–50%. This argues that the SFC with the Tildenet was improperly located since the SFC with 50% Coresa produced values in good agreement with those from the larger collectors.

It appears from the experiences in Chile and Oman that the SFC can be used to predict the output of much larger fog collectors having the same mesh material. Care must be taken to site the SFC in a representative location or to use several SFCs to cover the entire section of terrain that the large collectors will occupy. It is worth noting as well that the SFCs in Oman provided acceptable data (COWIconsult 1990) at collection rates up to 160 L m^{-2} day^{-1} and that on one occasion an omnidirectional SFC collected 300 L m^{-2} day^{-1}.

8. Discussion

The construction and use of a simple inexpensive fog collector has been described and its use as a standard (SFC) is proposed. Its applications are many, since the measurement of the deposition of fog water to vegetation at higher elevations has been largely neglected in hydrological studies, and since the need for potable water in developing countries is leading to the consideration of fog as a new water resource. A fixed fog collector mounted in a vertical frame is the most practical for simplicity of construction and maintenance and will result in the lowest costs. The large variability in fog deposition rates with altitude and topography leads to the need for the deployment of SFCs in large numbers. For this purpose, the collectors can be used with nothing more than a container to store the accumulated amount of water. In more elaborate installations, a data logger can record the water output continuously as well as wind speed and direction information. A standard fog collector site that includes wind speed data and conventional rain gauge data can also provide information on the relative proportions of fog and precipitation being collected.

It is recommended that serious consideration be given to the widespread installation of standard fog collectors in mountainous areas to assess the contribution of fog water to the sustainability of these sensitive regions. The contribution fog makes to the wet deposition of pollutants to mountain forests is well accepted. The same attention should be given to monitoring the real and the potential water inputs from fog to high-elevation areas.

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APPENDIX

Costs and Sources of Materials

The 35% shade coefficient, polypropylene, UV protected, black mesh can be ordered from Coresa in Chile. Mesh with a horizontal line spacing of 1.3 cm should be specified as other line spacing is available. Cost at this time is less than $0.25 U.S. per square meter. Expected lifetime in field use appears to be about ten years. The mesh is available in 8-m-wide rolls in essentially any length. A folded 8-m-wide mesh will make a double-layered 4-m-high fog collector. To order, write or call:

Coresa,
San Nicolás 630,
Casilla 14072,
Santiago 13, Chile.
Tel. (56-2)5521344 FAX (56-2)5521638

An essentially identical polypropylene mesh can be ordered from Marienberg S.A. in Chile. The same specifications should be given.

Marienberg S.A.,
Exposición 202,
Santiago, Chile.
Tel. (56-2)6898981 FAX (56-2)6892888

Another source of UV protected mesh is Tildenet Ltd. in the United Kingdom. The SD 40% standard, black, polyethylene mesh is very similar to the polypropylene meshes described above. It is available in 4-m-wide rolls in lengths of 100 m. Expected lifetime, quoted by the manufacturer, is three to five years. Cost is four to five times higher than for the Chilean meshes.

The company is represented by a worldwide network of distributors.

Tildenet Ltd.,
Longbrook House,
Ashton Vale Road,
Bristol BS3 2HA,
England.
Tel. (44-272)669684 Fax (44-272)231251

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