

Urban Dew Collection Under Semi-arid Conditions: Jerusalem

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ABSTRACT

A dew collecting experiment was initiated in late May 2003 on a roof in Jerusalem using passive radiative dew condensers. Several collectors were installed using different substrate material in order to assess collector performance. The condensers consisted of a 1 m² insulated flat pan, and set at a 30° angle to horizontal (planar approach). We report here on one of the collectors that used a special thin foil made of TiO₂ and BaSO₄ microspheres embedded in polyethylene (made by OPUR, France). Dew quantities were measured manually each morning. Almost 33 litres of dew were collected over 12 months using the OPUR dew foil. Maximum monthly dew yields were obtained during the rainless hot summer months of July (3.7 litres), August (6.1 litres) and September (5.0 litres). These same months also registered the highest daily dew yields, sometimes reaching almost 0.5 litres/m². This is despite the much shorter evening period for radiative cooling. For selected evenings, the chemical properties of the collected dew were analysed.

1. INTRODUCTION

Israel has a relatively high frequency of annual dew occurrences, despite the perceived dry climate (Evenari et al., 1982; Goldreich, 2003). In fact, the climate ranges from arid in the south, semi-arid to Mediterranean in the central to northern half of the country, and sub-humid at the northern borders. Because no standard sensor exists to quantify dew deposition, it is hard to compare and interpret measurements made on a variety of substrates using differing approaches. It is thus not surprising that only in the last 10-20 years has dew research branched out to focus on questions related to dew deposition, collection, and modelling (Beysens, 1995; Beysens et al., 2003; Jacobs et al., 2000; Richards, 2004; Zangwill, 1996).

In recent years, passive dew collection has become of increasing interest (Muselli et al.,

2002; Nillson, 1996) because of its potential to be used for drinking and domestic purposes. This is of special importance to developing countries situated within arid to sub-tropical regions where millions live with limited access to clean water. Dew collection, however, is equally applicable to island, rural and isolated settings. According to Gleick (1996), between 2-5 litres per day are the minimum water requirements for human survival. This is an amount that can be attained through a modest dew collection set-up.

Current research on passive dew collection has examined and tested materials and surfaces that can be used (i.e. Takenaka et al., 2003; Beysens et al., 2003).

A dew collecting experiment was initiated in late May 2003 on a roof at the Hebrew University of Jerusalem, Jerusalem (31° 47' N, longitude 35° 13' E; elevation 780 m a.s.l.; urban population

app. 650,000; rainless from about May to September) using passive radiative dew condensers. The condensers consist of 1 m² insulated flat pans (Fig. 1), set at a 30° angle to horizontal (planar approach), each covered with a different substrate to compare dew recovery from different materials. Gravity induced the drops to flow into a collecting trough and bottle. Dew quantities were measured daily.

The purpose was to find a surface with optimal properties of strength, resistance to high temperatures and UV, lightweight, easy to install and maintain, inexpensive, and that encourages radiative cooling. We report here on one of the substrates tested, namely a thin foil (4 mm thick) made of 5% volume of TiO₂ microspheres 0.19 μm diameter and 2% volume of BaSO₄ microspheres of 0.8 μm diameter embedded in a polyethylene matrix (made by OPUR, France). This material is currently being used in several other studies and thus allows for international dew recovery comparisons.



Figure 1: View of the rooftop dew collector setup in Jerusalem.

2. PREVIOUS DEW COLLECTION AND MEASUREMENT IN JERUSALEM

In the 1940s, measurements were made to collect or measure dew in Jerusalem. Shalem (1973) reported on dew measurements he carried out between 1940-47 using a 30 x 50 cm surface (Fig. 2). His method involved a drop-size calculation rather than actual collection.

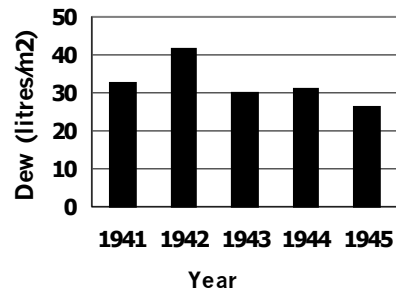


Figure 2. Annual dew amounts for 1941-45 as determined by the drop size method of Shalem (1973) (data converted to litres/m²/year).

Duvdevani (1947) developed an “optical method” of dew estimation, using calibrations of dew drop size observed on a wood block to provide a mm equivalent. Data for Jerusalem for 1945 is provided in Fig. 3. One mm dew depth/m² is the equivalent of 1 litre of water. The potential dew collection for 1945 would be about 24 litres. This is almost the same amount as reported by Shalem (1973) for 1945.

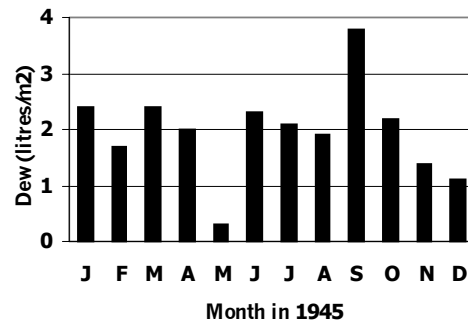


Figure 3: Duvdevani monthly dew deposition for Jerusalem, 1945 (153 dew events), converted to litres/m².

3. RESULTS

In the present study, 33 litres of dew/m² were collected over 12 months (June 2003-May 2004)

using the OPUR dew foil (Fig. 4). There were 176 dew events, 122 days without dew, 58 rain days, and several days with missing data. There were also 5 evenings observed with dew but that did not produce a dew yield in the collector. Of interest was that the maximum monthly dew yields were obtained during the dry hot summer months of July (3.7 litres), August (6.1 litres) and September (5.0 litres). Daily dew maximums also occurred during the same months, sometimes reaching almost 0.5 litres/ m²/night. This is despite the much shorter evening period for radiative cooling. Note that June 2004 had more than twice the dew collected in June 2003. Figure 5 provides a histogram of daily dew collection amounts.

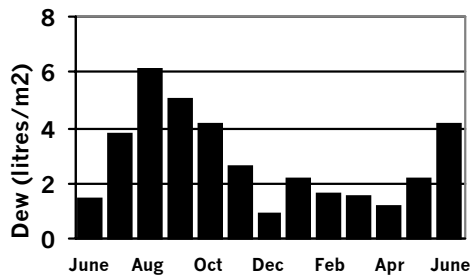


Figure 4. Monthly dew amounts (litres/m²) in Jerusalem from a 1 m² collector using OPUR foil, June 1, 2003–June 30, 2004.

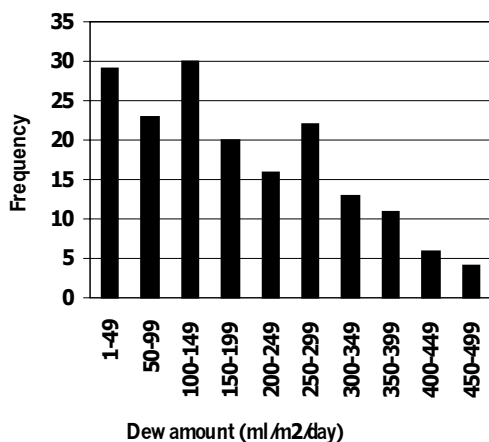


Figure 5. Histogram of daily dew amounts (ml/m²) in Jerusalem obtained from a 1 m² collector using OPUR foil, for June 2003–May 2004, in 50 ml increments.

4. DEW CHEMISTRY

Sixteen Jerusalem dew samples were taken for preliminary analyses of major and trace ions of the dissolved constituents. An additional 4 dew samples, obtained from a Negev desert site (Nizzana, app. 140 km SW of Jerusalem), were also analyzed for comparison.

Anions by Ion chromatography : Each water sample was passed through a Reverse Phase filter and a 0.2µm filter. Anions were determined using a DX-300 Ion Chromatograph (Dionex Corporation, Sunnyvale, California), with an AS4A analytical column and guard column, and an Anion Micromembrane Suppressor. Measurements were calibrated using standards from Dionex and Altech.

Elements by ICP/AES : Water samples were passed through 0.45µm filters. Analyses were conducted on portions of the samples, versus multi-element standards. Elements were determined in the tested solutions by inductively coupled plasma atomic emission spectrometry. An ICP-AES, model “Spectroflame Modula E” was used (Spectro GMBH, Kleve, Germany) with a cross-flow nebulizer. The power level was 1.2 kW, coolant flow - 15 l/min, auxilliary flow 0.5 l/min and nebulizer flow - 0.5 l/min. Observation height (where relevant) was 10 mm above the coil. Results are given as mg element per litre. Each result represents the average of three separate measurements.

For this preliminary evaluation, we selected 4 parameters, SO₄, Cl, Si and Na/Cl. Figure 6 presents Si ion (mg/l) data versus the equivalent ratio Na/Cl. The four desert samples from Nizzana, and some of the Jerusalem samples, are close to the ratio of 1, pointing to a possible dissolution of Halite, a common fraction of arid soils, while lower values might be related to maritime air borne salts (0.86). All Na/Cl values above 1 (about 1.2) are related to the dissolution of fine dust particles, in which Na silicates are known to occur. For most of the Jerusalem samples, sulfate is enriched as compared to chloride (Fig. 7), yielding concentrations up to 0.73 meq/l versus maximal chloride of about 0.2 meq/l. On the other hand, for the chloride ion range 0.2-0.72 meq/l, the sulfate concentration does not exceed 0.47 meq/l, both for Jerusalem and Nizzana. Thus, for this preliminary dew analyses, the chemical composition of the dew in Jerusalem is affected by local pollution of sulfur,

probably due to vehicles, as well as maritime and arid air mass contributions.

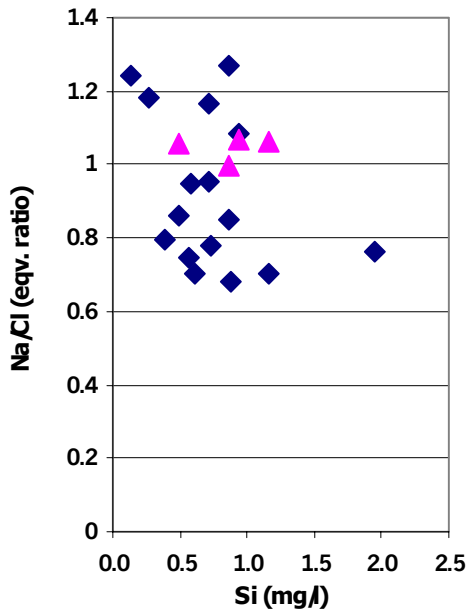


Figure 6: Si ion (mg/l) data versus the equivalent ratio Na/Cl for 16 Jerusalem dew samples and 4 desert (Nizzana) samples. Squares=Jerusalem, Triangles=desert samples.

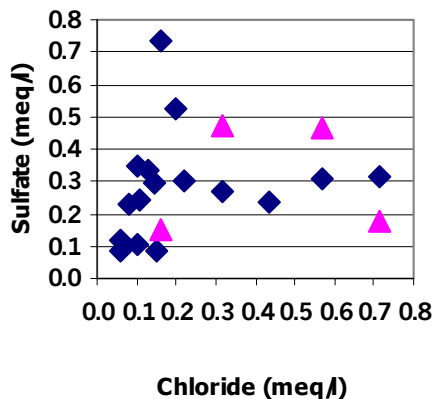


Figure 7: Sulfate and chloride content for 16 Jerusalem dew samples and 4 desert (Nizzana) samples. Squares=Jerusalem, Triangles=desert samples.

5. CONCLUDING COMMENTS

Dew should be considered as a potential resource, especially for areas where dew is known to occur but water is limited. Although

the daily amounts are not large per m², one should consider that homes or other structures could utilize the roof surface area to collect significant amounts of dew. Further work is needed on finding or developing inexpensive materials that can enhance dew yield as well as improve collector design.

6. REFERENCES

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