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Dew, fog, drizzle and rain water in Baku (Azerbaijan)

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ABSTRACT

Dwindling supplies of fresh water and climate changes have drawn attention to the need to find alternative sources of water globally. This study examines the potential of the semi-arid region of Baku (Azerbaijan) to exploit in particular dew, but also fog, drizzle and rain water. The Absheron Peninsular suffers from scarceness of water and non-hazardous water sources. Measurements were taken in this region on a 30° inclined plane passive condenser over a year (1/4/2010–31/3/2011) to determine the contribution and validity of using these alternative sources of water. The results show a significant relative contribution from these sources during this period (rain: 84 mm; dew: 15 mm; fog: 6 mm; drizzle: 13 mm). The fact that rain was measured within 23 km from the main station leads to uncertainties in its relative contribution. However, at least for the year under study, there are fair indications that collecting dew, fog and drizzle in addition to rain can significantly increase the collected atmospheric water with value estimated on order 40% ± 20%.

1. Introduction

Global warming and the diminution of clean fresh water in many areas of the world have made alternative source of water like rain, drizzle, fog and dew more attractive. When rain is lacking, fog can be an interesting source of water where conditions are favorable (Schemenauer and Cereceda, 1991, 1994; Cereceda and Schemenauer, 1996; Olivier and Van Heerden, 1999; Olivier and Rautenbach, 2002; Marzol, 2002; Marzol and Sánchez Megía, 2008). Dew, which is passive condensation of atmospheric water vapor on a substrate exposed to nocturnal sky, is a more ubiquitous phenomenon. Several studies (Nikolayev et al., 1996; Nilsson, 1996; Zangvil, 1996; Awanou and Hazoume, 1997; Kidron, 1999; Alnaser and Barakat, 2000; Muselli et al., 2002; Beysens et al., 2003, 2006; Berkowicz et al., 2004; Gandhidasan and Abualhamayel, 2005; Kalthoff et al., 2006; Sharan, 2006, 2011; Moro et al., 2007; Kidron et al., 2011; Sharan et al., 2007, 2011; Lekouch et al., 2012; Uclés et al., 2013; OPUR, 2015; for a review see Tomaszkiewicz et al., 2015) reveal that dew in some arid or semi-arid areas cannot be neglected with respect to precipitations. There has been recent improvement in passive dew condensers construction, which now approach, under favorable meteorological conditions, the theoretical limit on order 0.8 $\mathrm{L m^{-2}\ day^{-1}}$ (Monteith and Unsworth, 1990; Beysens, 1995, 2006; Berkowicz et al., 2004).

Located in a semi-arid region, the Baku region (Azerbaijan) (Fig. 1) is located on the southern shore of the Absheron Peninsula, which projects into the Caspian Sea. The peninsula of Absheron draws most of its fresh water from the Caucasus. Reserves of water per head or by square kilometer are less than those of other regions of the Southern Caucasus and the Confederation of Russia. The territory suffers from scarceness of water, especially during the dry season that lasts from June to October. Two rivers, Kura and Araz, constitute 80% of water reserves in Azerbaijan. According to comments from the Ministry of Environment and Natural Resources of the Republic of Azerbaijan, most of the rivers that cross the country are contaminated with hazardous materials. In the capital, tap water is not potable.

The average annual rainfall is low, 200 mm or less. Mean relative humidity is, however, high (over 70%), which makes drizzle a frequent phenomenon. Dew, although not referenced, also should be abundant, although strong winds, which can hamper dew formation, are frequent (Baku is known as the "city of winds").

In order to determine in Baku the potentiality of other sources of water than rain, and in particular the contributions of dew, fog and drizzle, measurements were carried out over 1 year (1/4/2010–31/3/2011). Although the latter were carried out for 1 year only, one nevertheless expects the results to give a significant vision of the different water contributions. The present paper reports and discuss those measurements and is organized as follows. In first section, measurements and methods are described. A second section is devoted to the evaluation of total atmospheric water with different contributions from rain, drizzle, fog and dew. Then a special section deals with the dependence of dew and fog on wind speed and direction, air relative humidity and cloud coverage. The paper ends by remarks concerning the relative contribution to atmospheric water of rain, drizzle fog and dew.

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Fig. 1. Measurement site at different scales.

Fig. 2. Condenser and its weather station.

2. Measurement and methods

2.1. Measurement site

Baku is located at −28 m asl and exhibits a temperate semi-arid climate (Köppen climate classification: *BSk*) with warm and dry summers, cool and occasionally wet winters, and strong winds all year long. Baku and the Absheron Peninsula on which it is situated, is the most arid part of Azerbaijan. Precipitation is light and around or less than 200 mm a year, occurring in seasons other than summer.

The measurement location (40° 21′ 20″ N, 49°, 48′ 43″ E) is located on a terrace of the botanical garden, in an open area (Figs. 1 and 2). The terrace is 3.40 m off the ground.

2.2. Data collection

The condenser is the same as currently used in many other studies (Berkowicz et al., 2004; Jacobs et al., 2008; for a review see Tomaszkiewicz et al., 2015). It is constituted (Fig. 2) by a 1 × 1 m^2 plane tilted at 30 degrees with horizontal as indicated to be the "best" angle (Beysens et al., 2003). The condenser cooling surface is oriented towards South. The condenser is thermally isolated from below by 30 mm thick Styrofoam and equipped with an hydrophilic radiative foil of 0.35 mm thickness manufactured by OPUR (2015). The foil is made of low density polyethylene enclosing a few % of TiO_2 and $BaSO_4$ particles with water insoluble food proof surfactant at its surface (Nilsson, 1996). The interest of such foil lies in its enhanced dew collection ability and its chemical inert properties.

In addition, to collect dew, the condenser also collects rain, drizzle and fog. The necessary corrections related to the tilt angle with horizontal (rain) or vertical (fog) are discussed below in Section 2.3. Concerning fog, a vertical mesh is generally used to collect water (Cereceda and Schemenauer, 1996). The difference in yield between an inclined plate and a vertical mesh has not been studied yet in details; one only notes the study by Lekouch et al. (2012) where both devices (mesh and inclined plates) gave the same yield by units of projected vertical area.

Water is collected by gravity in a gutter and the corresponding volume is measured by a pluviometer. The resolution of water collection is 0.014 $\mathrm{L\,m^{-2}}$. The measurements are averaged over 1 h. The pluviometer was calibrated by gently pouring different volumes of water and measuring the response of the weather station. It was found that the conversion ratio mm-condenser/mm-station is 8.51×10^{-3}.

An automatic weather station is placed nearby (Fig. 2). Air temperature, T_a, dew point temperature, T_d, and relative humidity RH are recorded every hour. An anemometer with stalling speed 0.5 m/s and resolution 0.1 m/s was placed at 1.5 m above the terrace, that is, 4.9 m above the ground. Wind speed (V) data are averaged over 1 h. We extrapolate them at $z = 10$ m height (V_{10}) by using the classical logarithmic variation (see, e.g., Pal Arya, 1988):

$$V(z) = V_{10} \ln(z/z_c)/\ln(10/z_c) \tag{1}$$

Here z_c (taken here to be 0.1 m) is the roughness length leading to $V_{10} = 1.18$ V.