Dew Harvesting From Atmosphere to Supply Water from the Mid Heights in the West Bank of Palestine

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Abstract — **A pioneer study for dew harvesting from atmospheric air in the mid highest of the west bank in Palestine was taking its place for a full year. Four galvanized iron plates each of 0.5 m^2 area were exposed to ambient air in a setup towards the 4 directions with 30º inclination each, available dew was collected each morning from these plates, amounts of water were measured against the average temperature and relative humidity for one year cycle. The northern exposed plate registered the maximum amount of dew which was 190 ml/m^2/night at average ambient temperature of 13ºC, and about 100% relative humidity, while other plates could produce between 130 and 153 ml/m^2/night. During this study results were measured during 59 nights. Unfortunately this year (2014/2015) was different from other years by the limited unusual dew production nights, the usual producing nights (below 19ºC temperature and above 40% relative humidity) about 120 nights could produce dew. In comparison to annual rainfall at Birzeit station (579.6 mm). 72 mm of dew (extra 8%) could be added to this amount if it is to be collected.**

Keywords— dew harvesting, relative humidity, ambient temperature, atmospheric air

I. INTRODUCTION

Water scarcity is one of the main problems to be challenged by Palestinian society. Because of the increasing in the rate of the population growth, increasing the demand of water for several uses in our agriculture, industry, and living life, and with limited water resources, Palestinians are always looking for alternative and renewable sources of water. Another important reason for this scarcity is the Israeli occupation that imposes restrictions and difficulties on using their underground water for political reasons. Starting from this point, this research is a trial to find solutions to produce water in Palestine, especially in the West Bank and Gaza strip.

Because of the variety of geographical location and strategic position of Palestine in the Middle–East, the existence of many water basins groundwater, rivers, and lakes, such as Jordan River basin and Tiberias Lake. These Palestinian water resources are controlled by occupation

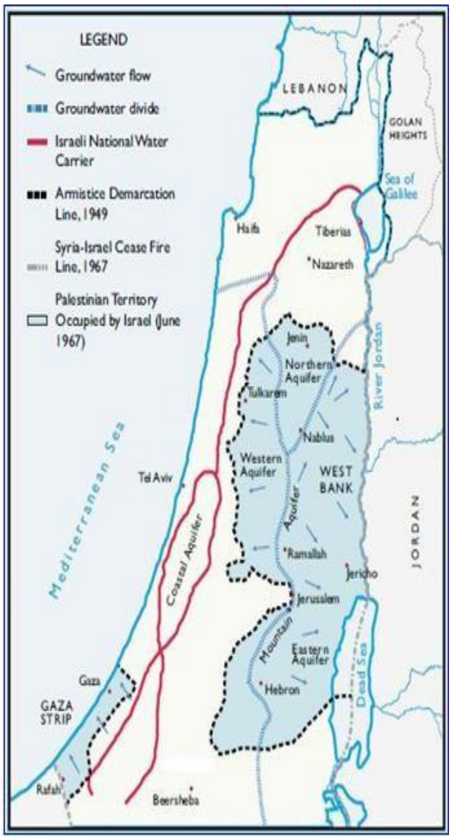

Figure (1) West Bank Map

which undermines any possibility for sustainable development and violates Palestinian's human right to safe, accessible, and adequate drinking water. Occupation controls a disproportionate amount of the two water systems that are shares with Palestine. It effectively controls 100% of Jordan River basin, more than 80% of underground water resources from the western (mountain) aquifer, and uses 85% of groundwater resources available in the West Bank for supplying 25% of occupation water consumption outside the West Bank. According to the Palestinian Water Authority [1] the amount of available water reaches to 349.2 million cubic meter in 2012, about 56.6 mcm bought from the Israeli Water Company "Mekorot", comprising 28% is supplied for domestic water sector.

The consumption of more than 500,000 occupation settlers is about six times higher than the 2.6 million Palestinians in the West Bank. Moreover, the Palestinian average water consumption of 73 liter per capita per day compared to 369 liters per capita per day for the settlers, this does not reach the minimum consumption level of 100 liters recommended by the World Health Organization (WHO).[2]

In addition to other many actions of occupation against the Palestinians, like irregularity in water supply across the West Bank; particularly in summer months, water distribution network loses of 30 –50% because of preventing of repair, no piped water at all in many West Bank villages, and many Palestinians must buy water, either from Mekorot, or private suppliers that makes it expensive. All these reasons motivate Palestinians to look seriously for other water resources, dew harvesting is one of them, and this is the main purpose of this research.

II. LOCATION AND WEATHER

According to the distinct location of Palestine in the east side of the Mediterranean Sea (latitude 31° 53′ 0″ N, longitude 35° 12′ 0″ E), it's allowed to have variety of climates, from humid Mediterranean, sub – Mediterranean, semi – arid, arid, and hyper – arid climate. Besides the variety in the temperatures and humidity ratios, that ranging between 2 ºC, 99% in winter and 40 ºC, 40% in summer. This diversity related to variety in topographical areas in Palestine. The central mountains in Palestine (contain mountains of Nablus, Ramallah, and Jerusalem) especially in Birzeit University Campus which is located in Birzeit – Ramallah (latitude 31°58′20″N, longitude 35°11′44″E) of height about 700 m above the sea level, it was selected as the location for set up of experiment to collect dew water data for

Figure (2): Birzeit town located in Ramallah – Palestine

the purpose of this research. The weather conditions and the geographical location of Birzeit were got from the Center of the Palestinian Meteorological Department for all the collecting data period [3].

III. LITTERATURE REVIEW

Atmospheric air contains water in a very small percentages, these amounts of water vapor depend upon atmospheric conditions such as pressure, temperature, location…etc.

Water in air is usually found in the vapor form, if the temperature is reduced to a certain level, condensation will occur; droplets of water will be produced, this temperature is called dew point temperature. Dew forms in cool nights with clear skies and light winds.

Figure (3): Dew water collector panels that used to collecting data in this research

Early efforts to condense dew were started by Greeks. Some of the most famous old practice and human-made dew harvesting sites include; the stone piles in Ukraine, dew ponds from southern England and even volcanic stone in the fields of Lanzarote. More such efforts were made in the early part of last century, efforts were mostly unsuccessful [4].

Montieth [5] registered peak dew yield on locations around the world on artificial surfaces. In Jamaica, South England, inside Occupied Palestine (Israel), and Munich it was 430 ml/m^2 , Germany Baltic coast 370 ml/m^2 , Moravia 250 ml/m^2 , France Montpellier 220 ml/m^2 Moscow 220ml/m^2 and Romania 170 ml/m^2.

Griga Sharan[6,7] used 3 materials in a prototype to measure dew, galvanized iron metal sheets (PETB) film, and aluminum sheet that were tested over a season, he collected (19.4 l/m^2) from PETB, followed by GI (15.6 l/m^2) and aluminum (9 l/m^2). Results show the total amount collected over the season differed to small extent with the orientation of units, he found out that the west and north oriented units are the best, east oriented units registered 5% less, while south oriented unites reported 15% less.

On a large scale dew collectors Sharan et. al.[7], investigated a very large dew and rain ridge collector in the Kutch area (India). They compared a 850m^2 dew condenser on ground facility that has a ridge and trough architecture, they compared it with 4 small 1m^2 condensers oriented to the 4 directions, a reduction of 42% in dew collection was registered by the large condenser, they explained that due to the orientation of the large condenser that was mismatched about 100^o to the right direction. They also calculated the price of production of 1 litter compared to the water price found in the market, they found out that it is 3% less.

Lekouch et. al,[8], investigated the dew, fog, and rain as supplementary sources of water in south-western Morocco. They used a dry land area to collect fog, dew, and rain for one year, they intended to use the water for alternative or supplemental sources of water. They built four passive dew condensers and a passive fog net collector, each of 1m^2 surface. During the observation period, 178 dew events (18.85) mm, corresponding to almost 40% of the yearly rain contribution (48.7 mm, 31 events). Their cost analysis showed that with little investment, the population of the arid and semi-arid coastal areas of south-western, North Africa could make dew water useful supplementary alternative water resource.

A comparison among dew amounts in different landscapes in Guangzhou, China was investigated by Youhua et al [9]. A significant difference between dew amounts in forests, residential, commercial, and industrial landscapes, and forests registered the highest amounts, followed by industrial, commercial, and residential landscapes respectively.

Other methods are used in dew harvesting such as high-mass system, radioactive collector, irradiative condenser, inverted pyramid dew condenser, fog-net catchers, she-oak trees, funnels, and so on. All these types are under test and research, some of them might be of useful interest [10-13].

Research on dew harvesting has not been started yet in Occupied Palestine, this is the first trial to investigate such a subject, so it will be a new door that could be opened for fresh water production with very low costs, this water production could help in some cases where the scarcity of water is found in some villages and areas due to the hard situation that Palestinians suffer. Dew harvesting is zero energy process, with no operating cost in order to get the fresh water.

IV. EXPERIMENTAL SETUP

Four galvanized iron plates each of 0.5 m^2 were mounted on a table base of 80 cm height, each plate was directed towards one direction (North, East, West and South), and the plates were mounted on a 30^o inclination and ended with collecting graduated flask for dew collection and measurement.

Data were collected in each day that dew formed at 8 O'clock in the morning at the beginning of the working day, measurements started from the beginning of May 2014 and ended by the end of April 2015, the total is one year, during this year 59 days could produce dew in different amounts for each plate. Two major factors were taken into consideration average of ambient temperature around 13 ^{o}C and relative humidity around 87%; since these are the most dominant factors affecting dew collection, other factors such as wind speed, with average speed less than 4 m/s from the west and north direction, and cloud coverage were not taken into consideration dew to their minor and small effect according to Youhua Ye *et al.* [9]

V. RESULTS

Amounts of dew were collected at the early mornings, the maximum recorded amount of collected dew water for the eastern plate was about 130 ml/m^2 twice, one was at ambient temperature of 8.5ºC, 98% relative humidity, and the other was at13ºC and 100% relative humidity the average value for all the period was about 63 mm.

Figures 4, 6, 8, and 10 show dew amounts against both ambient temperature and relative humidity, while figures 5, 7, 9, and 11 show by Minitab the combined effect of temperature and relative humidity on the amounts of dew.

For the western plate, the maximum dew amount was 153 ml/m^2 /night at ambient temperature of 13 ºC and humidity ratio of almost 100%, the average amount was about 88 ml, while the northern plate registered up to 190 ml/m^2 at ambient temperature 13 ºC and humidity ratio almost 100with an average amount of 74 ml. The southern registered a maximum dew amount of 130 ml/m^2 /night at ambient temperature of 8 ºC and humidity ratio almost 100%, with an average annual amount of 76 ml. doing a simple average for all these collectors results a 75 ml for annual dew collection.

A linear relation for both variables with dew amount were correlated, all the equations and average amounts are tabulated in Table (1)

According to Palestinian meteorological department Birzeit annual average rainfall is 579.6 mm, if this amount is to be collected, an addition amount of 72 mm dew could be collected, this means extra 8% of water from dew could be harvested above annual rain collection.

VI. DISCUSSION

It is known that dew is a natural phenomenon, and it is condensation is a natural physical process. In fact the impact factors for dew amounts are complicated, generally, the formation of dew is referred to aerodynamic and thermodynamic, surface meteorological parameters and surface properties.

Results showed that dew amounts are increased with increasing relative humidity started at 40% and above, which was consistent with many other investigations [8], based on a certain air pressure the air water vapor is related to the dew point, which is the lowest temperature that water vapor in air begins to condensate.

Ambient temperature is another kind of impact factor on dew formation, that dew was highly influenced by temperature. There is a negative relationship between temperature and collected dew especially if the temperature is above the dew point, dew ceased to form at 19ºC and above.

Wind speed is also considered as an impact factor on dew formation, since the average wind speed in the mid heights of the west bank are low, 0.1-2 m/s, its effect was negligible in this study, the differences in maximum and average amounts may refer to wind directions, that is why the northern panel recorded the highest dew values, since the wind direction in this area is mostly from west and south which effect on the amounts of the dew by carrying water droplets with moving air.

Table (1): Linear relationships between the dew water amounts, ambient temperature, humidity ratio and their averages and highest amounts in each direction.

Direction	**Dew amounts .vs. Ambient Temperature**	**Dew amounts .vs. Humidity Ratio**	**Average dew amounts during the whole period [mL/m^2]**	**Highest dew water amounts [mL/m^2]**
East	$y = -0.8979x + 74.801$ $R^2 = 0.0054$	$y = 0.9834x - 27.541$ $R^2 = 0.0549$	62.85	130
West	$y = -1.9634x + 114.37$ $R^2 = 0.0157$	$y = 2.0663x - 101.05$ $R^2 = 0.1568$	88.32	153
North	$y = -2.6648x + 109.52$ $R^2 = 0.0305$	$y = 1.298x - 44.985$ $R^2 = 0.0656$	74.24	190
South	$y = -0.6085x + 83.636$ $R^2 = 0.0025$	$y = 1.2054x - 35.445$ $R^2 = 0.0766$	75.59	130

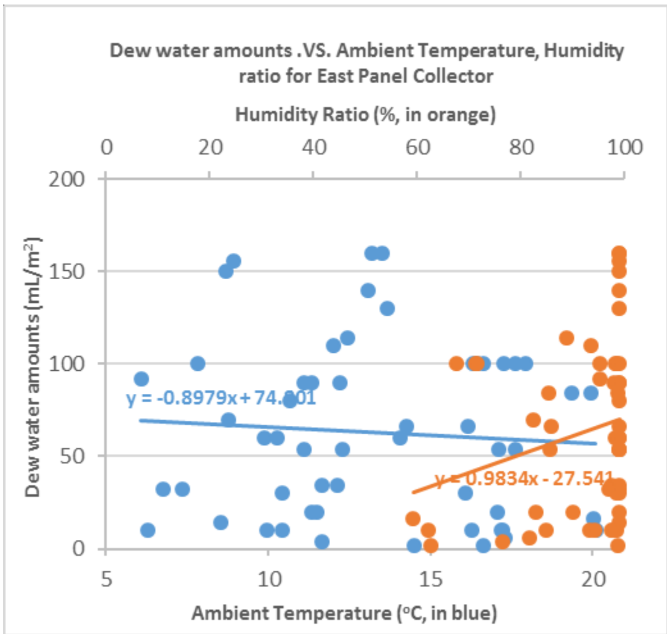

Figure (4): Dew water amounts relationship with ambient temperature and humidity ratio from the Eastern panel.

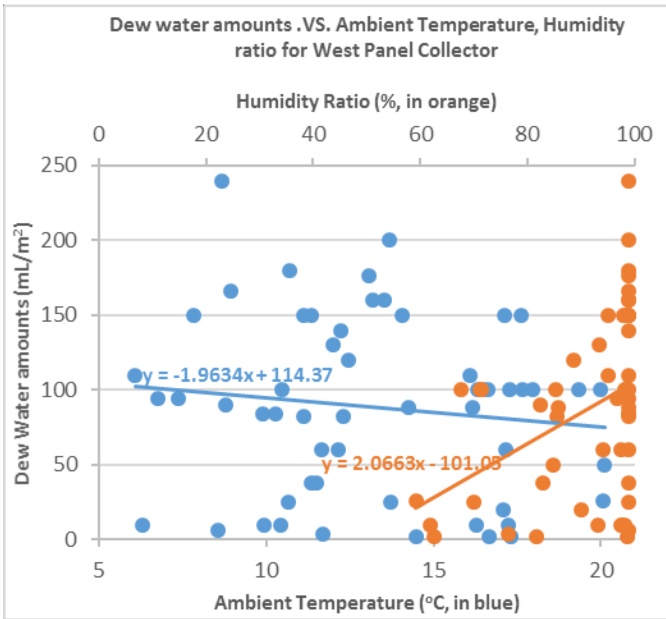

Figure (6): Dew water amounts relationship with ambient temperature and humidity ratio from the Western panel.

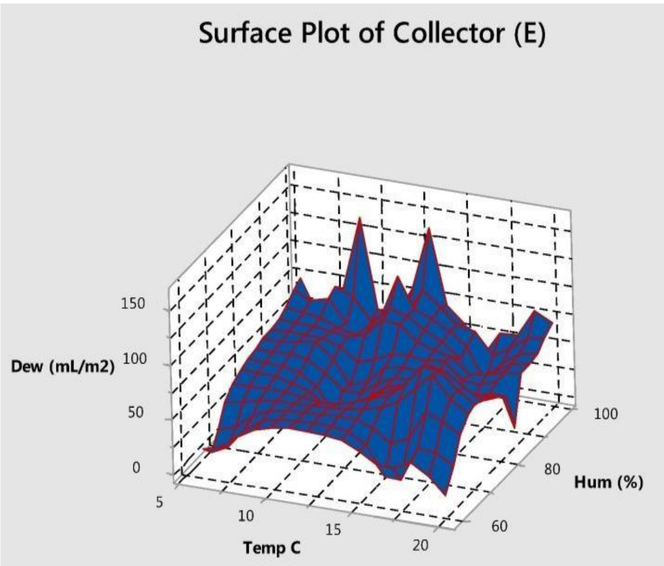

Figure (5): Dew water amounts that collected from the Eastern panel of dew collector device.

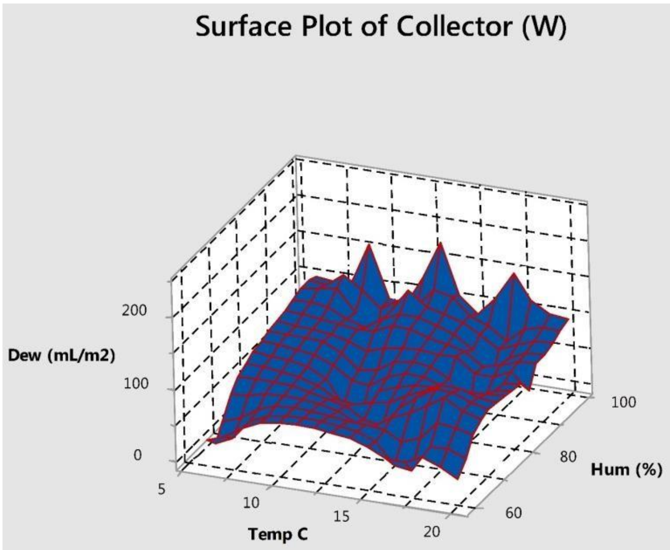

Figure (7): Dew water amounts that collected from the Western panel of dew collector device

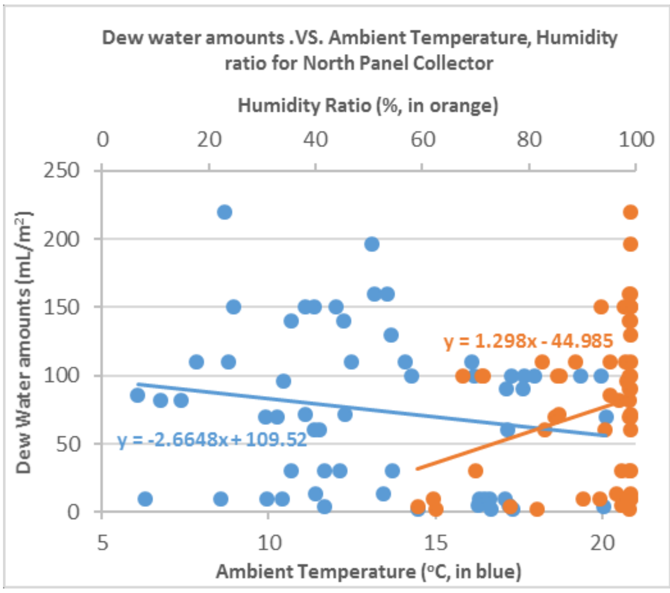

Figure (8): Dew water amounts relationship with ambient temperature and humidity ratio from the Northern panel.

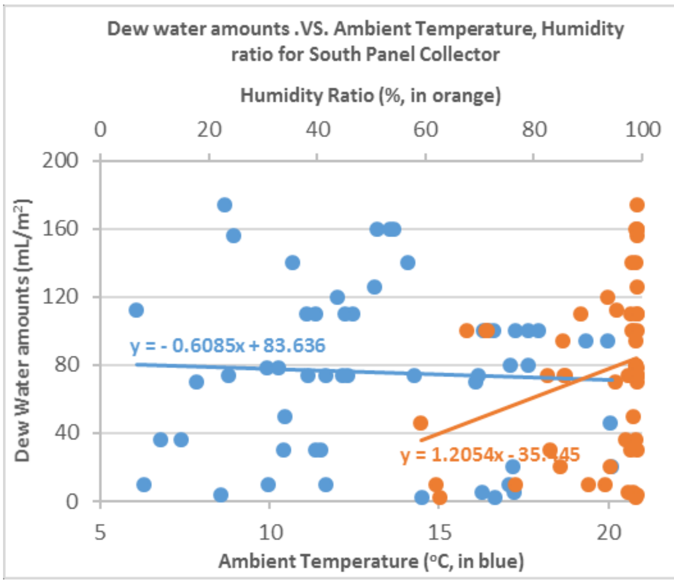

Figure (10): Dew water amounts relationship with ambient temperature and humidity ratio from the Southern panel

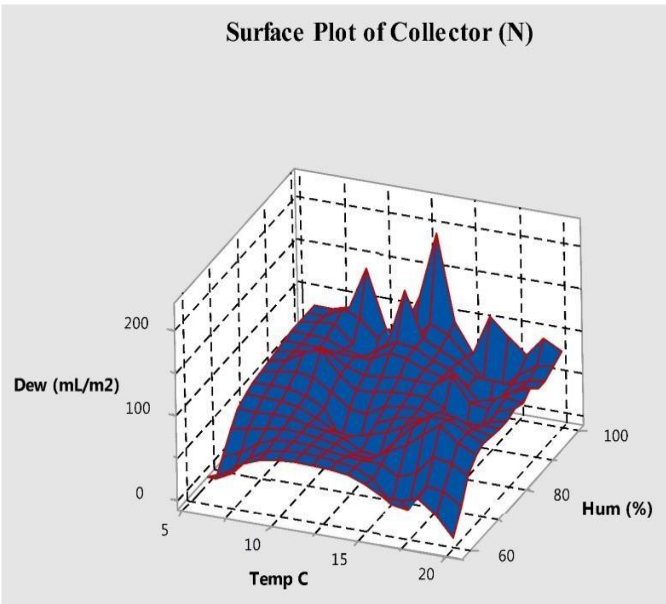

Figure (9): Dew water amounts that collected from the North panel of dew collector device

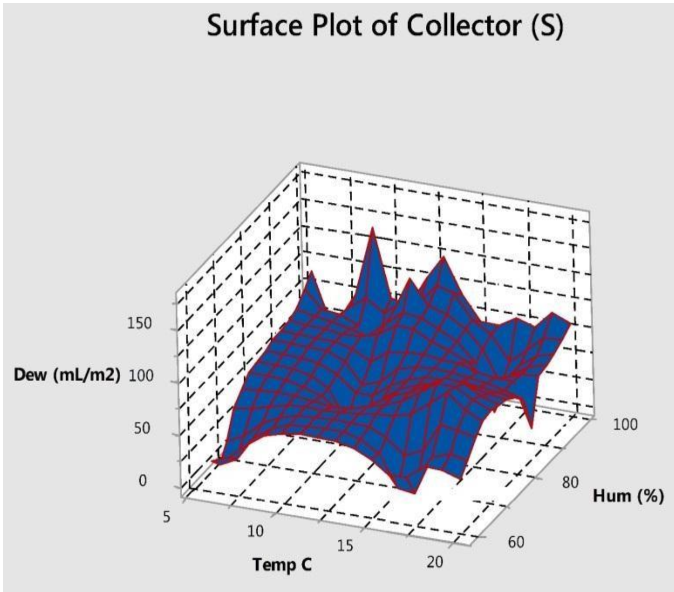

Figure (11): Dew water amounts that collected from the Southern panel of dew collector device.

VII. CONCLUSION

A basic idea about dew harvesting in the mid heights of the west bank of Palestine was taken. It was found that with humidity over 40% and ambient temperature below 19ºC, there is a possibility to harvest dew from the galvanized iron roofs especially for agricultural halls and firms which are widely spread in Palestine. Large amounts could be collected in humid nights that could decrease the difficulty of getting potable water for agricultural and home uses in the rural areas. Part of Palestine which is the western costal region which is very humid is prepared for more dew collection. In general the geographical location of Palestine in the middle-East made it a suitable location for the dew harvesting.

VIII. AKNOWLEDGEMENT

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