WATER HARVESTING FROM FOG AND AIR HUMIDITY IN THE WARM AND COASTAL REGIONS IN THE SOUTH OF IRAN

COLLECTE DES EAUX DU BROUILLARD ET DE L'HUMIDITE DE L'AIR DANS LES REGIONS CHAUDES ET COTIERES AU SUD DE L'IRAN

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ABSTRACT

The south coastal area of Iran being adjacent to the Persian Gulf and Oman Sea, it is humid and has a high potential of water harvesting from fog and air humidity. In this research, data were collected from 10 synoptic stations adjacent to the Persian Gulf and Oman Sea, for investigating feasibility of water harvesting from fog and air humidity. The data used in this study included hourly dry and wet temperature, relative humidity, wind direction and velocity and the dew point temperature. By the use of these data, various parameters such as the atmosphere water vapor pressure, saturated vapor pressure and the absolute humidity of the atmosphere were estimated. According to the investigations carried out in this study, it was clear that the cited regions had the potential to harvest fog and moisture from the humid atmosphere for 160 - 360 days. The annual mean water harvested through this technique varies between 6.7 lit/m^2/day at Abadan station to 156.3 lit/m^2/day at Chabahar station. It is worth noting that the maximum amount of water harvested from the stations near the coastal areas is during summer while at stations far from the coastal areas this happens during winter.

Key words: *Fog water harvesting, Thermodynamic process, Plastic net, saturated vapor pressure.*

RESUME ET CONCLUSIONS

L'approvisionnement en eau pour les personnes dans les zones arides et semi-arides du monde a acquis une grande importance. En dépit de l'aridité et la rareté de l'eau due à de petites quantités de précipitations dans certaines régions du globe, les sommets sont parfois couverts de nuages bas ou les zones côtières sont entouré par le brouillard. C'est pourquoi

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l'une des méthodes d'approvisionnement en eau de ces régions pourraient être récupération de l'eau à travers les brouillards, les nuages de montagne ou de manière générale de l'humidité de l'air. Depuis le début des années 1960, différents pays et organisations internationales ont porté sur la question de la récolte de brouillard dans leur ordre du jour.

L'humidité de l'air lors de son point de saturation et la condensation a des caractéristiques spécifiques. À cet égard, l'humidité relative entre 68 à 90 pour cent est approprié pour récupération de l'eau et avec une humidité relative d'environ 90-98 pour cent avec des conditions différentes de l'aérosol, les conditions sont appropriées pour la formation de brouillard. Ces deux processus sont parmi les processus de condensation thermodynamique et sont considérés pour récupération de l'eau de l'humidité du brouillard et de l'air.

La zone côtière du sud de raison de le golfe Persique et la mer d'Oman d'humidité, en plus de sa température élevée et sa grande capacité d'absorption de l'humidité de l'Iran, a un potentiel élevé de récupération de l'eau du brouillard et humidité de l'air. Dans cette recherche, les données ont été recueillies auprès de 10 stations synoptiques adjacentes dans le golfe Persique et la mer d'Oman, pour enquêter sur récupération de l'eau du brouillard et humidité de l'air.

Enfin, selon les études réalisées, récupération de l'eau de l'humidité du brouillard et l'air serait possible pour environ 160-350 jours dans une année, tandis que le nombre moyen de jours avec des brouillards est maximum 41 jours. En outre la récolte de l'eau varie de 6.7 lit./m2/day dans la station Abadan à 156.3 lit./m2/day dans la station de Chabahar. Le montant maximal potentiel de l'eau qui pourraient être récoltées à partir de stations à proximité des zones côtières se fera pendant l'été tandis que dans des régions éloignées de la côte, il semblerait pendant l'hiver. La quantité d'eau qui pourraient être récoltés dans la station de Chabahar comme un échantillon représentatif de la régions côtières du nord du golfe Persique est considérable à travers le monde. A noter que la quantité d'eau récoltée grâce à des méthodes similaires dans la région de Zafar (Sultanat d'Oman) est d'environ 30 lit./m2/day. La principale raison serait l'air allant de la péninsule arabique, tandis que dans les parties nord des flux de l'air du Golfe Persique sur le Golfe Persique et porte une plus grande quantité d'humidité pour récupération de l'eau. Par conséquent, en investissements à réaliser sur cette industrie, nous pouvons non seulement fournir de l'eau potable pour les régions où l'eau rare, mais aussi l'approvisionnement en eau pour l'agriculture dans le sud de l'Iran.

Mots clés : *Collecte des eaux du brouillard, processus thermodynamique, filet en plastique, pression de vapeuur saturante.*

(Traduction française telle que fournie par les auteurs)

1. INTRODUCTION

Supplying water for people in arid and semi arid regions has gained high importance. In spite of aridity and water scarcity due to small amounts of precipitation in some parts of the globe, mountain peaks are frequently covered with clouds or low costal areas are surrounded by fog. Therefore one of the methods of supplying water to these regions could be water harvesting from fogs, mountain clouds or generally speaking from air humidity. Since the beginning of the 1960s, different countries have included the issue of water harvesting in their agenda (Sharan, 2006).

Chile and Peru are the pioneers in using this technology. In the coastal areas of these countries, due to cold oceanic flows, rainfall seldom occurs. Actually, cold oceanic wind flows immediately saturates the air with moisture and forms fog in more than 200 days of the year in these regions. Therefore these regions have a high potential in water harvesting from fog (Sharan, 2006).

The air humidity in the stage of saturation and density holds specific characteristics. When relative humidity is between 68 to 90% or higher, the conditions are appropriate for water harvesting. Between 90 to 98% RH, the situation is favourable for fog formation. These two processes are considered as thermodynamic processes which are used for water harvesting and fog formation (Esfandyarnajad et al, 2009). Apparently, clouds and fogs are both results of the atmospheric vapor condensation and the deference between them is in their height .Usually fogs are formed near the ground surface and they could exist a few meters above the surface while clouds exist far from the ground surface. In mountainous areas due to existing clouds around the mountain sides it is difficult to dfferentiate the clouds from the fogs.

The technology used for extracting water from fog and air humidity is simple and accessible. The only instrument used for this is a rectangular net of plastic with different shapes. This screen net is situated above the ground surface by wooden or metal panels. Atmospheric moisture condenses on the net, flow down and is led to a collector/reservoir. The screen is vertically positioned in the direction of wind so that the wind flow could transfer the humidity to the screen. The material used for the screen and its density affects the water produced via this system. For instance in Eltofo, Chile the efficiency of a screen net with a density of 35% and polypropylene, was 30 %.This means that 30 % of the total humidity which has passed the screens was harvested. In this project the dimensions of the screen were 2m width and 24m tall with an area of around 48 m2 (Sharan 2006). In addition to the device efficiency, climatic factors such as wind, the absolute air humidity and temperature, all affect the water harvested from fogs, clouds and air humidity. In the projects carried out in Chile, the water harvested from each square meter per day was around 5-13 liter (Sharan, 2006). Figure 1 demonstrates a device applied for fog water harvesting in Lima, Peru.

Fig. 1. A water harvesting device in Lima, Peru (National Geography news portal, 2009)

Oliver and Rautenbach (2002), have located water harvesting devices in two areas of the south Africa, one of which is at a higher altitude and the other on the river banks. The water harvested at higher elevation was 2 lit/m^2/day and at the coast, it was about 4.6 lit./ m^2/day. Shanyengana and Henschel have used a device in Nabibia. In this study it was assumed that water harvested form the air humidity could be used for rural potable water. Qadir et al. (2007) pointed out the importance of unusual water supplies such as fog water harvesting in food security. Muselli et al. (2009) investigated fog water harvesting in different regions of Dalmatian in Crovasia. The average water harvested through this study was around 20 mm/year.

The important point in the above studies is that they have been carried out in cold climates under the influence of cold oceanic wind flows. I such places, the air has low moisture that in the warm coastal regions. The water harvested through this method in Zafar, Oman was around 30 lit/m^2/day on an average. This shows the maximum absolute humidity in this country (Esfandyar et al., 2009)

In Iran this has been practiced in two areas, one in the altitudes of Khorasan province and the other in Hormozgan. In Khorasan the water harvested was between 0.5-3 lit/m^2/day (Moosavi & Shabanzadeh, 2008). A research project was also carried out for the Ministry of Energy, Iran by Esfandyarnejad et. al. (2009) and the average potential water harvested from the air humidity for Hormozgan with the device working with an efficiency of 20% was between 46-121 lit/ m^2/day. This was much higher than other studies. In this study we have tried to investigate the potential water harvesting for the northern coasts of the Persian Gulf and Oman Sea and its implementation methods.

2. METHODS AND MATERIAL

2.1 The geographical location of the study area and the data used

The southern part of Iran is surrounded by the Persian Gulf and Oman Sea. These regions due to their low latitude (25-31 degrees North) and proximity to sub-tropical high pressure is quite appropriate for water harvesting from fogs and air humidity. The air temperature being high causes evaporation of the sea water and due to the dynamic high pressure conditions the vapor could not rise and condense. Therefore the situation is good for forming a relatively high humidity (Alijani and Kavyani, 2003).

In order to investigate the water harvesting from the air humidity, 10 synoptic stations around the Persian Gulf and Oman Sea were selected. The inputs were, wet and dry bulb temperatures, dew point temperature, relative humidity and the direction and velocity of wind which was measured every 3 hours at 0, 3, 6, 9, 12, 15, 18 and 21 (GMT) for an eight year period from 1992-1999.Table 1 and Figure 2 demonstrate the names and specifications of the stations used as well as their lay out in the south part of Iran or the northern part of the Persian Gulf and Oman Sea.

Table 1. The specifications of synoptic stations

Station Name	Position(Degree)		Elevation (m)
	E Longitude	N Latitude	
Abadan	48.25	30.37	6.6
Bandar Abbas	56.37	27.22	9.8
Bandar Daier	51.93	27.83	4
Bandar Lengeh	54.83	26.53	22.7
Bandar Mashahr	49.15	30.55	6.2
Bushehr	50.82	28.97	9
Chabahar	60.62	25.28	8
Jask	57.77	25.63	5.2
Kangan Jam	52.37	27.82	655
Kenarak Chahbahar	60.37	25.43	12

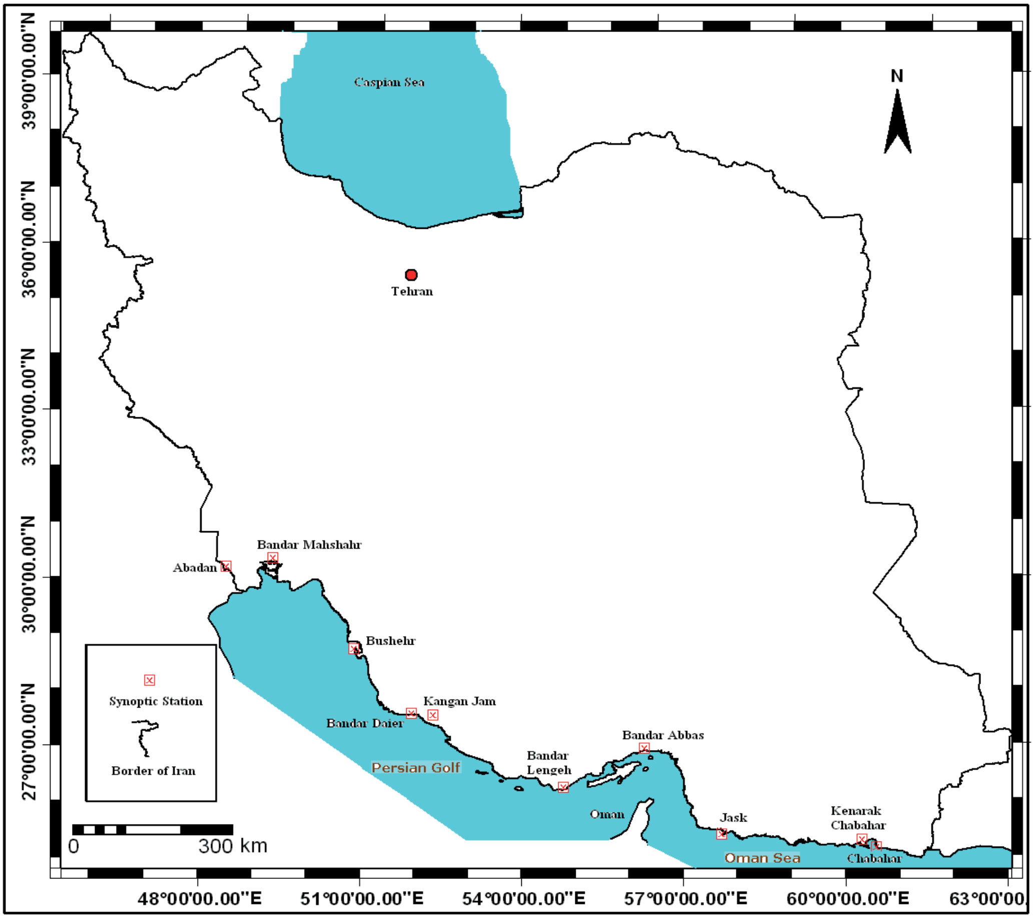

Fig. 2. The layout of Synoptic stations and the conditions of the studying area

2.2 Extracting required parameters from the inputs

One of the main parameters for determining the water harvesting from fogs and air humidity is the absolute humidity which is defined as the humidity in grams per cubic meter of air in a specific temperature. This parameter could be extracted by the following formula (Alizadeh, 2002):

$$M_t = \frac{217 \times e}{T + 273.3} \qquad (1)$$

In the above formula, M_t is the absolute humidity (g/m^3), e is the air vapor pressure (mili bar) and T is the air temperature (^{0}C). In this study, the three hour air temperature and the relative humidity were available but the air vapor pressure was calculated by the following formula:

$$e_s = 6.11 \exp\left(\frac{17.27 \times T}{T + 273.3}\right) \qquad (2)$$

$$RH = \left(\frac{e_s}{e}\right) \times 100 \qquad (3)$$

Where, e_s is the air saturated vapor pressure and RH is the relative humidity per percent. The air humidity flow could be determined by knowing the absolute air humidity and wind velocity and direction. Esfandyari et al (2009) determined that the appropriate humidity for fog formation would be around 98% but the humidity required for water harvesting would be around 69%.Therefore by knowing the wind direction suitable for supplying the air humidity and the speed of supplying the humidity, the water harvesting could be calculated through the following formula.

$$\begin{cases} if, RH \geq 69\% \Rightarrow WH_3 = 3 \times M_t \times U_2 \times E_{eq} \times 3.6 \\ if, RH \prec 69\% \Rightarrow WH_3 = 0 \end{cases} \qquad (4)$$

In equation number 4, WH_3 is the potential water harvested through the air humidity during 3 hours. The reason for this equation being used for 3 hours is that the inputs from synoptic stations is 3 hourly and we assume sustainable conditions during this period. E_{eq} in the above equation is the device efficiency which is around 10-30%.This depends on the device type and the climatic conditions of the region. The efficiency achieved in one of the projects in Chile was 30% (Sharan, 2006). Therefore the efficiency of 10, 20 and 30 percent have been considered in this study. U_2 is the wind velocity at 2 m height from the ground. As the wind velocity in synoptic stations is obtained 10 meters from the surface, the following equation is used for calculating the wind velocity in 2 meters (Alizadeh, 2002):

$$\frac{U_z}{U_0} = \left(\frac{Z}{Z_0}\right)^{0.5} \qquad (2)$$

The other point to be considered is the direction of the device which should be in the direction of the dominant wind in the region which provides air humidity. In this study the best direction for receiving humidity form the air is calculated via Eq. 4 by including 8 directions as follows:

Between 0-45 degrees (d1), 45-90 degrees (d2), 90-135 degrees (d3), 135-180 degrees (d4), 180-225 degrees (d5), 225-270 degrees (d6), 270-315 degrees (d7), and finally 315-360 degrees (d8). The device could receive the humidity in any direction from an angle of 45 degrees. The efficiency of the device was considered 10, 20 and 30 percent. Therefore in each synoptic station 24 conditions were calculated by considering the device efficiency and the wind directions.

3. RESULTS AND DISCUSSION

3.1 Investigating the conditions of the region for water harvesting

The southern margins of Iran has warm weather and the saturated vapor pressure or the air humidity storage capacity is high. In order to investigate the difference, during an eight year period, the number of foggy days as well as the number of days with more than 69% humidity in each station were determined. Table 2 demonstrates the number of days with the above mentioned specifications as well as the air temperature during the same period for each of the stations.

Table 2. The average number of foggy days

Station	Mean Foggy days	Mean Harvesting days	Temperature (C.D.)
Abadan	13	164	25.1
Bandar Abbas	24	346	26.4
Bandar Daier	6	263	27.2
Bandar Lengeh	20	301	27.8
Bandar Mashahr	21	195	25.6
Bushehr	27	324	24.9
Chabahar	41	348	26.3
Jask	3	291	27.6
Kangan Jam	13	132	24.2
Kenarak Chahbahar	11	318	28.1

According to Table 2, the maximum number of foggy days in the northern margins of the Persian Gulf and Oman Sea are 41 days while the number of days for fog formation (days with a relative humidity or above 69%) is maximum 346 .This of course varies from 132 days at Kangan Jam located at the mid regions to around 346 at Bandarabbas station. According to Table 1, Kangan station at an altitude of 655 m is one of the highest stations in the region and it is quite different from other stations. On the other hand, the number of days with fog formation is low while the number of days for water harvesting is considerable, indicated by the high humidity due to the high temperature and evaporation from the sea level, but at the same time due to the high saturated vapor pressure, the air occasionally reaches the saturated vapor pressure and the number of days for fog formation is one month or less.

3.2 The average annual water harvesting potential from fog and air humidity

The water harvesting potential could be calculated by the use of equation 4 for 8 directions of wind and equation 8 for 3 efficiencies of the device. Tables 3 to 5 demonstrate the mean annual water harvesting potential for the efficiency of 10 and 30 per cent, respectively. In addition a comparison between different parts of the world with the study region for water harvesting plans is carried out. In Tables 3 to 5 the colour spots show the maximum water harvesting amount. The yellow spots hold the first score while the second colour holds the next score. According to the information provided the maximum water harvesting is in d3 direction with an angle equal to 90-135 degree (west to south west).The amount of water harvested from the air humidity in this direction and with an efficiency of 10% is between 2.5 lit/m^2/day at Kangan station to 156.3 lit/ m^2/day at Jask Island.

By taking into account all of the directions the average annual water harvesting potential from the air humidity in the whole region at 10% efficiency would be around 6.7 to 156.3 lit/m^2/day. This amount is equal to 13.4, 312.5, 20.1 and 468.6 lit/m^2/day for 20 and 30% efficiencies. These figures are average annual amounts, much higher than other plans submitted in Table 6. For instance in Zafar, Oman the water harvested is 30 lit/m^2/day with three months of high humidity while at other times of the year it is much less.

Table 3. Average potential annual water harvesting from the air humidity with an efficiency equal to 10 percent (lit./m^2/day)

Station	Wind Direction							
	d1	d2	d3	d4	d5	d6	d7	d8
Abadan	0.9	1.6	6.7	6.3	1.9	0.4	5.4	2.6
Bandar Abbas	13.5	7.7	13.4	13.3	46.3	5.4	1.8	4.7
Bandar Daier	0.5	0.5	34.5	21.5	9.2	1.8	14.4	2.3
Bandar Lengeh	3.5	48.2	26.7	14.4	40.5	24.8	2.1	2.5
Bandar Mashahr	1.2	1.9	20.5	12.1	5.9	1.0	6.5	4.4
Bushehr	2.2	3.4	9.2	4.6	4.5	2.3	17.0	11.2
Chabahar	11.4	25.4	92.7	86.1	60.9	51.5	43.6	10.9
Jask	3.6	20.2	156.3	81.8	39.8	29.6	30.8	6.1
Kangan Jam	0.3	4.3	2.5	1.0	16.3	1.8	1.6	0.4
Kenarak Chahbahar	3.4	22.0	40.3	30.9	29.3	5.4	2.0	0.8

Table 4. Average potential annual water harvesting from the air humidity with an efficiency of around 20 percent (lit./m^2/day)

Station	Wind Direction							
	d1	d2	d3	d4	d5	d6	d7	d8
Abadan	1.8	3.2	13.4	12.7	3.8	0.8	10.8	5.3
Bandar Abbas	27.0	15.3	26.8	26.6	92.5	10.7	3.6	9.4
Bandar Daier	1.1	1.0	69.1	43.0	18.4	3.6	28.9	4.6
Bandar Lengeh	6.9	96.3	53.3	28.8	81.0	49.6	4.3	5.1
Bandar Mashahr	2.4	3.7	40.9	24.1	11.8	2.1	13.1	8.9
Bushehr	4.4	6.8	18.5	9.3	9.0	4.7	34.1	22.4
Chabahar	22.9	50.9	185.4	172.1	121.8	103.1	87.2	21.7
Jask	7.3	40.3	312.5	163.5	79.6	59.3	61.6	12.2
Kangan Jam	0.7	8.7	5.0	2.1	32.7	3.6	3.2	0.7
Kenarak Chahbahar	6.8	44.0	80.5	61.8	58.6	10.8	3.9	1.7

Table 5. Potential average annual water harvesting from the air humidity with efficiency equal to 30 percent (lit./m^2/day)

Station	Wind Direction							
	d1	d2	d3	d4	d5	d6	d7	d8
Abadan	2.7	4.8	20.1	19.0	5.7	1.2	16.2	7.9
Bandar Abbas	40.5	23.0	40.2	39.9	138.8	16.1	5.4	14.2
Bandar Daier	1.6	1.5	103.6	64.5	27.6	5.4	43.3	6.8
Bandar Lengeh	10.4	144.5	80.0	43.3	121.4	74.3	6.4	7.6
Bandar Mashahr	3.6	5.6	61.4	36.2	17.7	3.1	19.6	13.3
Bushehr	6.6	10.2	18.5	13.9	13.5	7.0	51.1	33.6
Chabahar	34.3	76.3	278.2	258.2	182.7	154.6	130.8	32.6
Jask	10.9	60.5	468.8	245.3	119.4	88.9	92.4	18.3
Kangan Jam	1.0	13.0	7.5	3.1	49.0	5.5	4.8	1.1
Kenarak Chahbahar	10.1	66.1	120.8	92.7	88.0	16.1	5.9	2.5

Table 6. Potential average annual water harvesting from the air humidity with an efficiency equal to 30 percent (lit./m^2/day)

Project Name	Harvested water	Notifications
Eltofo-Chile	3.1	75 stations
Zafar-Oman	30	In 3 humid Months
Haiti	5.5	-----
Coastal South Africa	2.5	-----
Mari-Peskop South Africa	11	Maximum 800 Lit\ m^2\day
Peru	3.5-9	-----
Haja- Yemen	4.5	-----
Chonkongo-Chile	3	-----
Khorasan-Iran	3.3	-----

3.3 The potential monthly variations of water harvesting from fog and air humidity

In order to investigate the monthly variations of potential water harvesting, figures 3 to 12 demonstrate the potential mean monthly water harvesting for each of the stations under study. Worth noting that, these figures have been extracted for the best water harvesting direction from the air humidity (directions which have had the maximum annual average in tables 3 to 5). According to figures 3 to 12 it could be seen that, the distribution of potential monthly water harvesting from the air humidity exists in 3 types: A- Regions far from the coast: The maximum potential in these regions is during the cold months and due to the severe increase in saturated vapor pressure during the warmer months this amount is decreased to its minimum. Abadan and Bushehr satations are amongst this category (apparently there are two coastal and non coastal synoptic stations in Bushehr but the non coastal one has been used in this study). B- Regions nearby coasts or marine climates: In these stations the maximum amount of water harvesting happens in the warm months while the minimum occurs in the cold period. The reason for this is the considerable increase in air humidity through water evaporation from the sea by the increase in air temperature. Bandarabbas, Bandar lenge chabahar and kenarak chabahar and Jask are amongst these stations. C- The third category have a situation in between the above mentioned stations. In these stations the monthly potential water harvesting varies in two ways, maximum and minimum. The water harvesting increases during winter and gradually decreases during spring but as the weather warms up it increases during summer and reaches it highest during July and August. Bandar Daier, Bandar Mahshar, Jask and Kangan are amongst these stations.

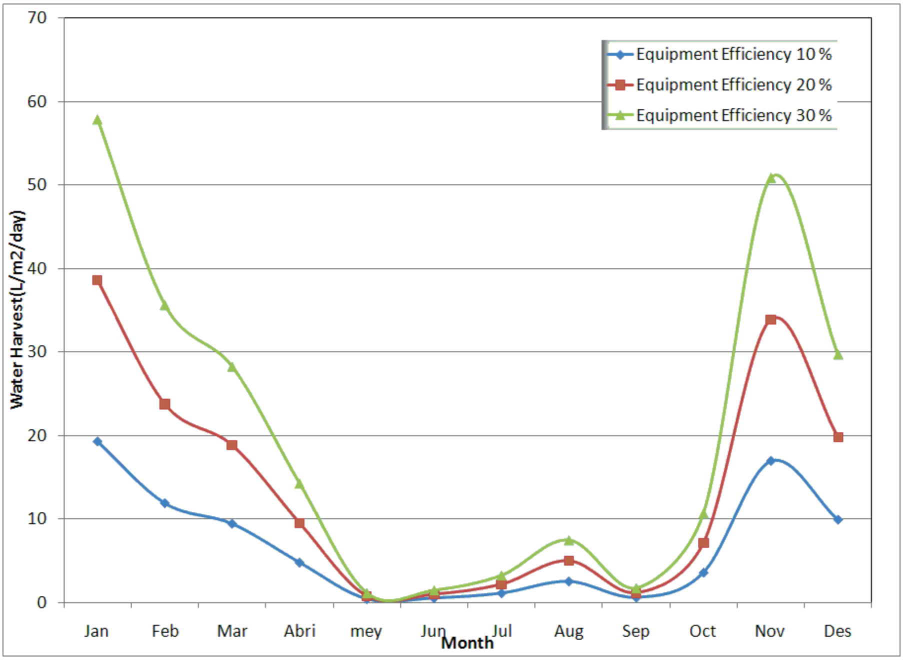

Fig. 3. The trend of monthly potential water harvesting from the air humidity for Abadan station

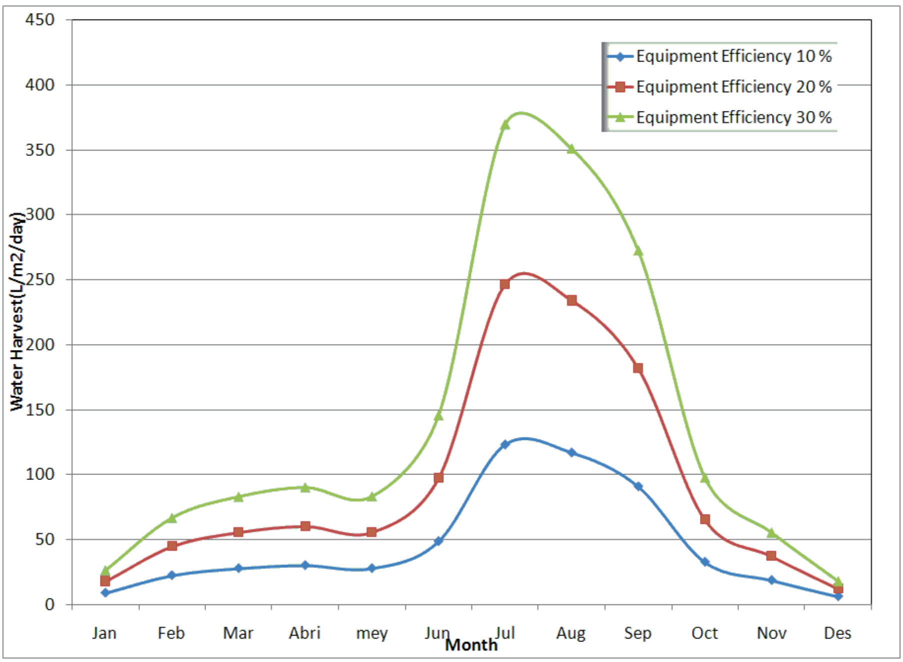

Fig. 4. The monthly trend of potential water harvesting form the air humidity for Bandarabbas station

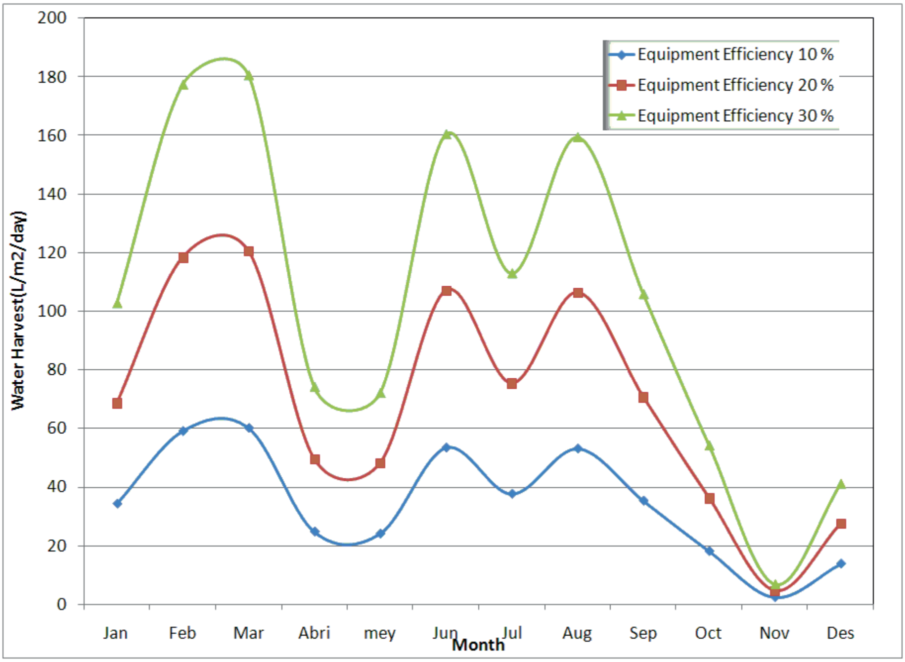

Fig. 5. The monthly trend of potential water harvesting form the air humidity for Bandar Daier station

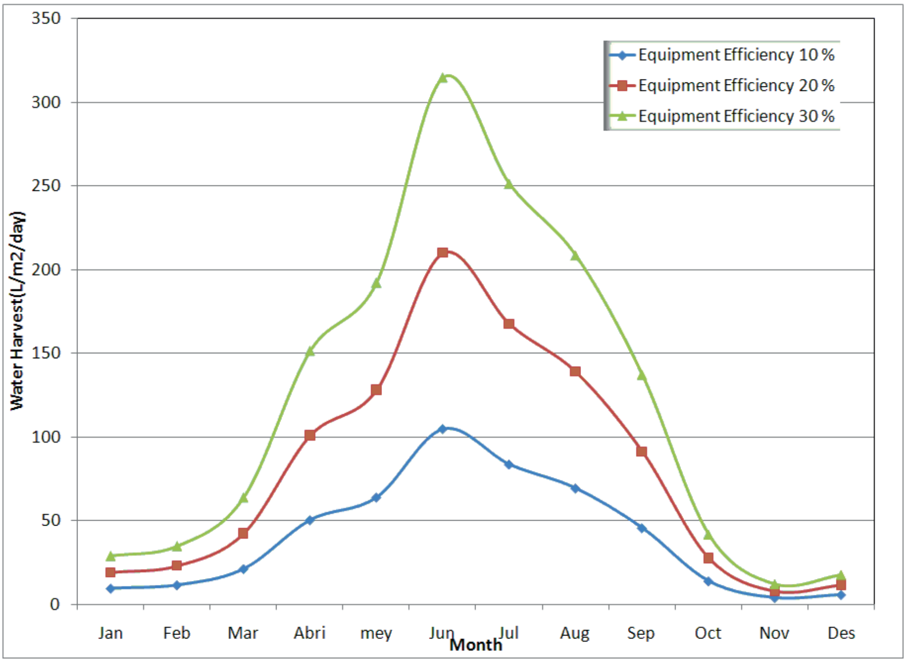

Fig. 6. The monthly trend of potential water harvesting form the air humidity for Bandar Lengeh station

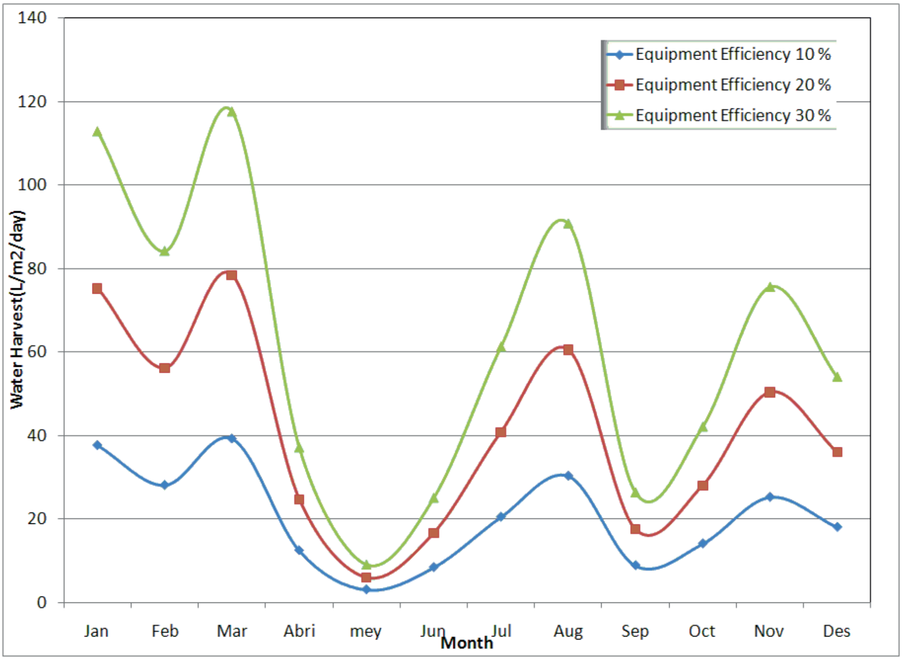

Fig. 7. The monthly trend of potential water harvesting form the air humidity for Mahshahr station

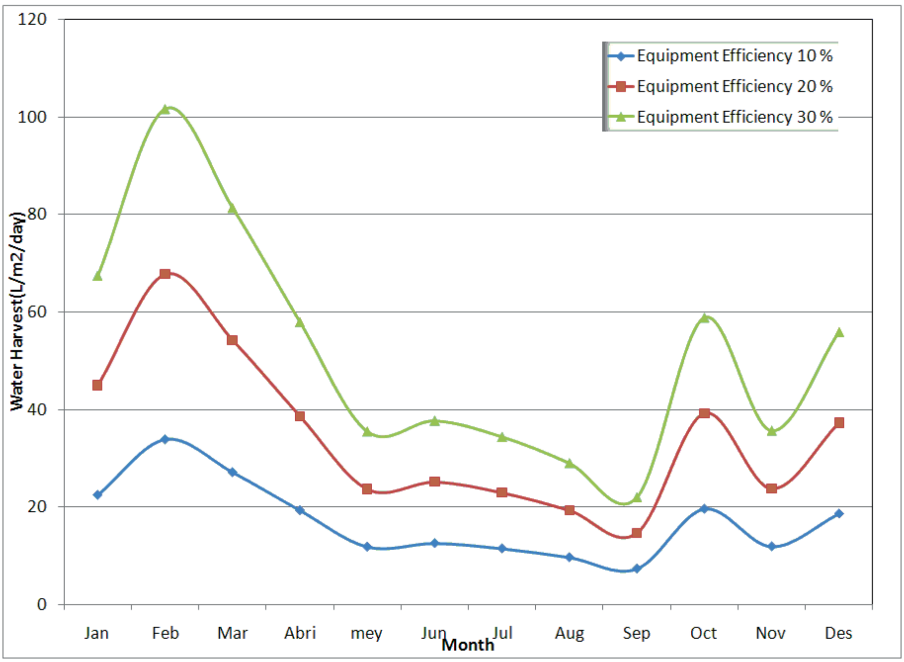

Fig. 8. The monthly trend of potential water harvesting form the air humidity for Booshehr station

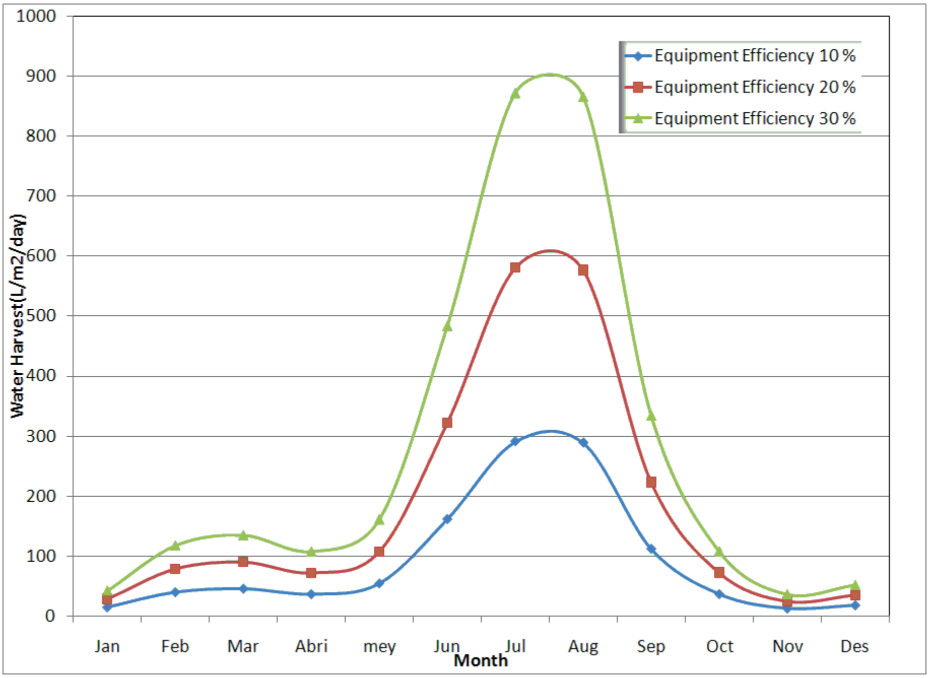

Fig. 9. The monthly trend of potential water harvesting form the air humidity for Chabahar station

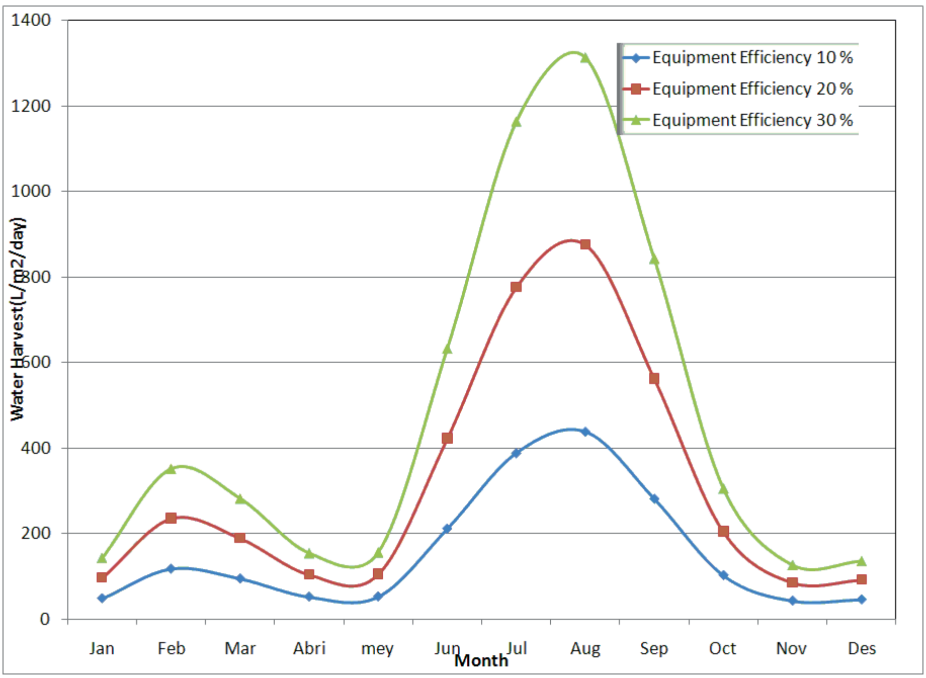

Fig. 10. The monthly trend of potential water harvesting form the air humidity for Jask station

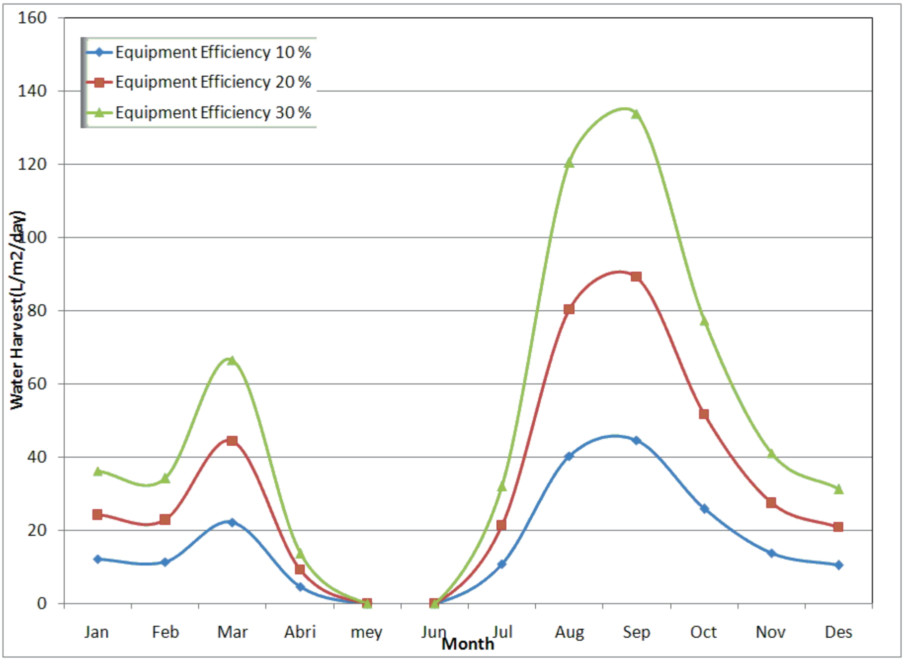

Fig. 11. The monthly trend of potential water harvesting form the air humidity for Bandarabbas station

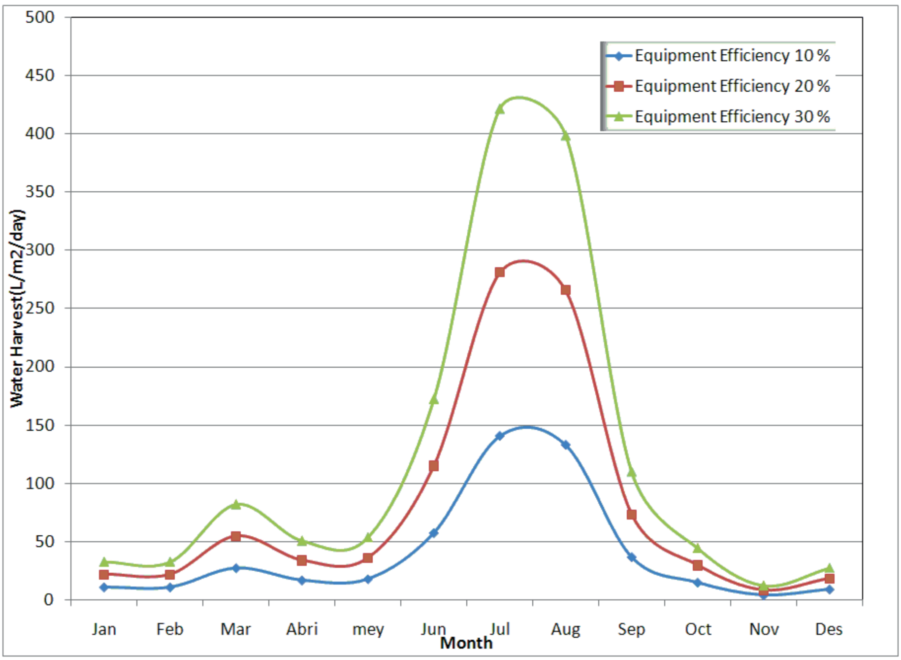

Fig. 12. The monthly trend of potential water harvesting form the air humidity for Kangan station

The other issue also demonstrated in the following figures, is related to the monthly potential water harvesting. This amount is maximum, between 42 to 438 lit./m^2/day for Jask Island with an efficiency equal to 10 percent and it is between 85 to 876 lit./m^2/day for an efficiency equal to 20 percent, and finally with an efficiency equal to 30 percent it is equal to 127 to 1314 lit./m^2/day. In addition the minimum amount with an efficiency equal to 10 percent is around 0.4 to 19 lit./m^2/day, with an efficiency equal to 20 % its 0.7 to 39 lit./m^2/day and with an efficiency equal to 30 % it is 1 to 56 lit./m^2/day. Worth noting that as shown in figure 1, Abadan station is not a coastal station but it has a high potentiality of water harvesting from the air humidity although quite far from the coast. This is a rare sample being compared with other stations. In addition, in many cases the amount of water produced is much more than the potable water required and the exceeding amount could be used for irrigation of the orchards and farms. This is practiced in the orchards of Atakama, Chile (Newsletter No. 22, FogQuest, 200).

REFERENCES

Esfandyar A., Ahangar, R., Kaalian, R., Poorhatefi, M., Sangchooli, T., Shafiei, R., 2009, Water harvesting from fog and air humidity in the coatstl areas (Hormozgan case study), research plan, Hormozgan regional water authority

Alizadeh, A., 2002, Applied hydrology, Mashhad Ferdowsi University

Alijani, B., Kavyani, M.R., 2003, Basis of meteorology, Samt publications

Moosavi Beigi, M., Shabanzadeh, S., 2008, Design and construction device for water harvesting from fogs and clouds (a new method for supplying water), Agriculture science and industry magazine, Ferdowsi mashhad university, No. 22.

FogQuest Newsletter, 2008, International Development Center, Vol. 22.

http://news.nationalgeographic.com/news/2009/07/photogalleries/fog-catchers-harvest-air-water-missions/index.html

Muselli, M., D. Beysens, M. Mileta and I. Milimouk, 2009, Dew and Rain Water Collection in the Dalmatian Coast, Croatia, Atmospheric Research, Vol. 92, pp. 455–463.

Oliver, J. and C.J. de Rautenbach, 2002, The Implementation of Fog Water Collection Systems in South Africa, Atmospheric Research, Vol. 64, pp. 227–238.

Qadir, M., B.R. Sharma, A. Bruggeman, R. Choukr-Allah and F. Karajeh, 2007, Non-Conventional Water Resources and Opportunities for Water Augmentation to Achieve Food Security in Water Scarce Countries, Agricultural Water Management, Vol. 87, pp. 2–22.

Shanyengana, E.S. and J.R. Henschel, 2002, Exploring Fog as a Supplementary Water Source in Namibia, Atmospheric Research, Vol. 64, pp. 251–259.

Sharan Gira, 2006, Dew Harvest, Center for Environment Education, pp. 84-92.