Iran. J. Environ. Health. Sci. Eng., 2008, Vol. 5, No. 4, pp. 269-276

EFFECTS OF CLIMATE CHANGE PROCESS ON COMFORT CLIMATE IN SHIRAZ STATION

[1]A. Shakoor, *[2]Gh. R. Roshan, [3]F. Khoshakhlagh, [4]Z. Hejazizadeh

[1]Faculty of Geography, Islamic Azad University, Larestan branch, Larestan, Iran

[2,3]Faculty of Geography, University of Tehran, Tehran, Iran

[4]Faculty of Geography, Teacher Training University of Tehran, Tehran, Iran

Received 16 January 2008; revised 13 May 2008; accepted 30 July 2008

ABSTRACT

Dwelling in cities and city development together with quick increase of population and development of industrial activities with unplanned consumption of fossil fuel have intensively increased pollutions with consequences which will cause different diseases in short period, will lead to some climatic oscillations and its environmental effects such as the change of desirable periods in view of comfort climate in long period. The objective point of view of this research was to study the climate in Shiraz and its effect on comfort conditions for human physiology. In this research, using 55 year climatic data (1952-2006), the relative humidity and temperature through the application Guni comfort climatic model, the desirable months for the comfort of human physiology have been determined in the five 11 year periods and the linear process of these changes have been estimated for the next 11 years. The results of this research show that the temperature trend in Shiraz station is increasing and most months have heating process in a way that it is expected that in the coming future, the cold months will have more favoring conditions for physiological comfort of residents and correspondingly in the warm months, heating tension will have remarkable increase.

Key words: Climate change, comfort climate, bioclimatic diagram, Shiraz

INTRODUCTION

The expansion of dwelling in cities and city development together with quick increase of population and development of industrial activities with unplanned consumption of fossil fuel have intensively increased pollutions that its consequences will affect people in the form of pulmonary diseases and the aggravation of cardio-pulmonary diseases in short period. It will also play a role as a factor in increasing climatic oscillation and its environmental effects such as the change of desirable months in view of comfort climate in long period. Climate change is a concept which can not be defined easily. But it can be studied in different views; for example the concept of climate change maybe considered as the effect of changes of daily temperature and relative humidity with time (minimum and maximum average). By this description, first the desirable climatic month for the human comfort in the past and present conditions are determined and then it is considered that by climatic change, the present desirable months will be changed to now conditions. The concept of human comfort is the collection of conditions which are suitable for at least 80% of people in view of temperature state, in other words, people feel neither cold nor warm. Some researchers know neutrality of temperature state as a more accurate term, since the human does not feel cold, warm and local discomfort due to climatic issues (Ghobadian *et al*., 1997). In such conditions, the human organism can keep its heating balance in the best possible form, without gaining energy. In the formation of human comfort conditions in climatic view, four elements of temperature, humidity, wind and radiation are important. Among these elements, temperature

*Corresponding author: rrowshan@ut.ac.ir
Tel: +98 21 6696 6552, Fax: +98 21 6640 4647

and humidity have more effects on health and comfort of human and for this purpose, most human comfort measurement models have been deployed on these two factors (Alijani,1993 ; Miguel *et al*., 2002; Frank, 2005; Miguel *et al*., 2005; Wang *et al*., 2005).
Considering the great effect of climate on human comfort, the man has ever seeking optimal usage of his surrounding climate and many scholars such as Gyger ,1965; Hoshoovar ,1965; Balafootis *et al*., 1987; Dier, 1989; Guny, 1989; Gerrigoor *et al.*,1987; Welt, 1998; Tampson *et al*., 1997; Hoshoovar, 2002; Mochida, *et al*., 2008 have paid attention to that. In this paper results of a study on the climate features in Shiraz station , relevant to climate comfort are stated.

MATERIALS AND METHODS

In this research, the relation between two main climatic elements, relative humidity and temperature, have been identified and studied in Shiraz station for five statistical 11 year periods from 1952 to 2006. Initially, the type of Shiraz climate was calculated using Eivanph method for each of the months of five statistical periods and general view of changes in the climatic components of the region were presented. In order to observe the climatic oscillations of the related station during the 55 year statistical period and considering the average of data for each period, the type of monthly climate has been identified. Therefore for this purpose, Eivanph humidity coefficient method has been applied (equation 1 and 2):

$$I = P / \sum E \qquad (1)$$

In the above equation, the denominator of fraction is the total value of evaporation in different months of year which can be calculated based on the following equations:

$$E = 0/0018\ (2.5+T)(100 - r) \qquad (2)$$

In which:
I: Eivanph humidity coefficient
T: mean of monthly heat temperature in ºC
r: mean of monthly relative humidity in percent
E: monthly evaporation value
P: annual rainfall value in mm
E: total of evaporation in the months of year based on (cm).

It is to be mentioned that if the output of this equation be $I \geqslant 1.5$, we will have a very frosty and humid climate and if the output be $I \leqslant 0.12$, the climate will be desert type.
The Bureau of Meteorology in Australia (2006) provides a website describing the importance of determining the apparent temperature (AT) in order to assess the thermal stress and therefore the human comfort level. Wind speed, air temperature, air humidity and solar radiation are taken into account based on a mathematical model of an adult walking outdoors in the shade, as proposed by Steadman (1984). This model is an extension of the initial definition of AT developed in the late 1970s to measure thermal sensation indoors. Both the heat index and the wind chill index are provided by the Bureau of Meteorology (2006) for people to make an educated choice regarding their activity. This is only one example where human comfort is analyzed in everyday life. A slightly different approach has been taken in the area of human biometeorology where the focus is on the development of comprehensive heat budget models, which take all mechanisms of heat exchange into account. Input variables include air temperature, water vapor pressure, wind velocity, mean radiant temperature including solar radiation in addition to metabolic rate and clothing insulation (Jendritzky *et al*., 2002). The complex heat budget model forms the basis of the development of a Universal Thermal Climate Index (UTCI), which is the subject of the COST Action 730 (http://www.utci.org).
Using Guni model, the comfort degree was estimated for the aforementioned 5 periods with linear correlation method, the estimated values of relative humidity and temperature for the next 11 years ending to 2017 have been obtained by Excel software and drawn in Guni bioclimatic diagram. In bio-climatic indices, the effort has been made to consider the simultaneous effect of environment heat and humidity and these indices have been

used in local and global scales. In this research, Guni Comfort diagram was used with its axis designed as temperature in relative humidity in percent. In the lateral parts of the diagram, the worst climatic conditions have been shown by freezing and heatstroke line. Considering the present humidity, radiation and rate of airflow, the comfort region has been drawn in the form of two approximate extended regions in the middle of diagram. Applying Guni Comfort diagram, the desirable months in view of physiological comfort have been identified. For this purpose, the air parameters such as the mean daily temperature, mean of minimum and maximum temperatures and the mean of daily, minimum and maximum relative humidity have been used. First, the aforementioned 55 year data (1952-2006) were averaged by a five 11 year periods and a long-term 55 year period. In the next phase, in order to show the bio-climatic condition of each month and each period, the averaged data of relative humidity and temperature have been used as follows:

A) The first case includes the mean of daily temperature and the mean of daily relative humidity. These two elements indicate the mean of daily bio-climatic conditions.

B) The second case includes the mean of daily maximum temperature and the mean of minimum relative humidity. The combination of these two elements indicate bio-climatic conditions in the warm hours of day.

C) The third case includes the mean of daily minimum temperature and the mean of maximum relative humidity; the diagram is to indicates bio-climatic conditions in the cold hours of night.

After determining the comfort climate (mean, day and night hours) for the aforementioned five periods, by using correlation equation as well as interpolating line and variance, different figures of climatic components, temperature and relative humidity, have been calculated and foreseen for the next eleven years, up to 2017. Finally, using the estimated figures for 2017, the average bio-climatic conditions, night and warm hours in different months of Shiraz station have been drawn in Guni bio-climatic diagram.

The aforementioned processes have been done for all components and periods separately and the results were drawn in Guni diagram.

RESULTS

Climatic conditions of Shiraz station

Identification of monthly climatic area for the five studied periods

Table1 shows the Eivanph humidity coefficient for Shiraz station for five 11 year periods(1952- 2006).

Table 1: Type of monthly climate of Shiraz station for the five 11-year periods (1952-2006) using Eivanph method

Terms	Months					
	Jan.	Feb.	March	April	May	June
1952-1962	26.52	4.37	0.0023	0.0000	0.0046	0.0240
1963-1973	13.69	1.61	0.0764	0.0000	0.0018	0.0012
1974-0984	15.85	1.22	0.2509	0.0000	0.0001	0.0225
1985-1995	19.25	1.53	0.0667	0.0002	0.0050	0.002
1995-2006	13.48	1.37	0.0834	0.0000	0.0171	0.0041
Terms	Months					
	July	Aug.	Sept.	Oct.	Nov.	Dec.
1952-1962	0.0000	0.22	1.10	7.17	9.96	36.62
1963-1973	0.0000	0.08	2.01	2.55	11.01	40.80
1974-0984	0.0054	0.13	0.84	5.02	9.29	43.90
1985-1995	0.0000	0.19	0.57	5.14	8.41	26.92
1995-2006	0.0047	0.01	0.68	3.53	8.96	30.26

These results indicate very frosty and humid climate for the months of January, February, March, November and December, but these coefficients have decreased in the recent years for these months. The climate for other months are considered as desert type with the humidity coefficient of these months decreasing in recent years. In general, considering the calculated coefficients for different months and periods, the conditions show more dryness in Shiraz station.

Results of regression method for different climatic components (relative humidity rainfall, temperature,…) one as fallows:

1- In all months, the mean of daily temperature showed a significant increasing trend, but in the months of January, February and March it is random.

2- The mean of minimum temperature in different months in Shiraz station has shown a significant increasing process, but the mean of maximum temperature for some months such as February, October and November has had a non-significant and low increasing process; as for some months such as January and March, it has had a non-significant low decreasing process and for the remaining months, the increasing trend of temperature has been variable between 2% to 5% level.

3- The remarkable point was the decrease in the mean of temperature difference for all months, and the decreasing trend of most months was significant in the level of 0.1%

4- The value of relative humidity (mean, maximum, minimum) and its trend for most months was decreasing decreasing and the process had a greater significant level for the minimum mean of relative humidity than two other components (mean and maximum of relative humidity).

5- The value of monthly rainfall and 24 h rainfall for most months showed decreasing trend that which were not significant.

6- The mean of wind vector indicated that the corner of blowing is approaching west from northwest with the significant of 0.1% for the months of April, December, 10% for the months of March and July and for the remaining months, this west approaching process was random. But the process of wind speed for most months was decreasing with significant of 0.1% for November and December, 2% for October and 10% for September, and it indicated the decrease of wind speed in Shiraz.

Fig. 1 shows fully significant and increasing process of daily temperature for the month of August with R= 0.68; in the same month, the mean of relative humidity with R=0.18 showed a decreasing and random process. This process has been done for all months and components but due to the great amount of data, we have sufficed to Table 1 as a sample.

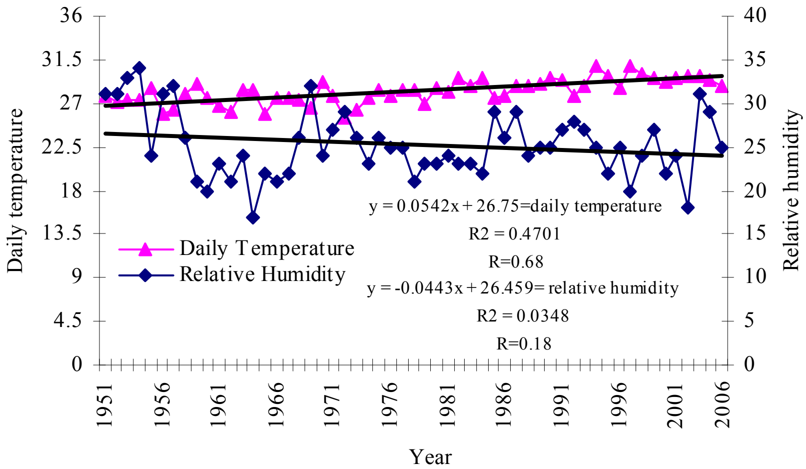

Fig. 1: The trend of changes for the mean of relative humidity and daily temperature of Shiraz station for August (1952-2006)

Guni heating comfort index

Average of daily bio-climatic conditions (Figs. 2-4)

A) In long-term average diagram (1952-2006), the months of May, September and June are located inside the comfort region and August is tangent with comfort region. July is above comfort region and it requires wind speed of 0.5 m/s to reach the comfort state. Other months are below the comfort region in a way that October is the nearest cold month to comfort region and January is the farthest. For example, in October there is a need to 150 watt/m^2 of heat or radiation energy and in January. to 900 watt/m^2 of energy to reach climatic comfort.

B) In the first 11 year period, May, September and June are in comfort region, August and July are tangent to comfort region and other months are far from comfort region.

C) In the second 11year period , August also entered the comfort region; July is still attached to the comfort region, but this situation has been changed again in the third period and August again went out of comfort region.

D) In the fourth 11 year period, October has got closer to the comfort region, but the remarkable point is the exit of June from comfort region. This condition is also seen in the fifth period with a little difference.

E) By estimating for 11 year period up to 2017,it is shown that the months of June, July and August are above comfort region, but it is expected that in the future these months take some distance from each other in comparison to the present situation. But September and May are in the comfort region as before May will have a significant change than before and may be in the next periods (the next 20 years); it will get out of the comfort region and October will substitute it. It is also observed that May and November are in the same horizontal length and this situation shows the same temperature condition for these 2 months in 2017; however January, February, and December are seen with the least change than the fifth course.

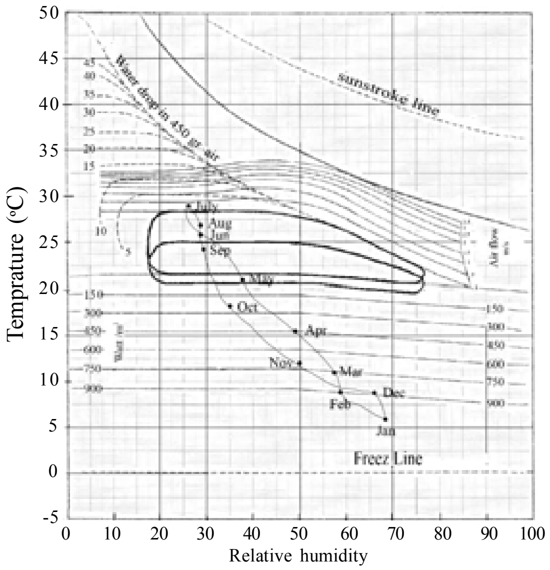

Fig. 2: Guni comfort climatic model average of daily bio-climatic condition for past term

Bio-climatic conditions in the warm hours of day

Fig. 5 shows the bio-climatic conditions in the warm hours of day for past term. Fig. 6 shows the bio-climatic conditions in the warm hours of day for present term and Fig. 7 shows bio-climatic conditions in the warm hours of day for future term.

A) Considering the long-term average, April is in the comfort region, but July is the farthest warm month from comfort region. This month requires

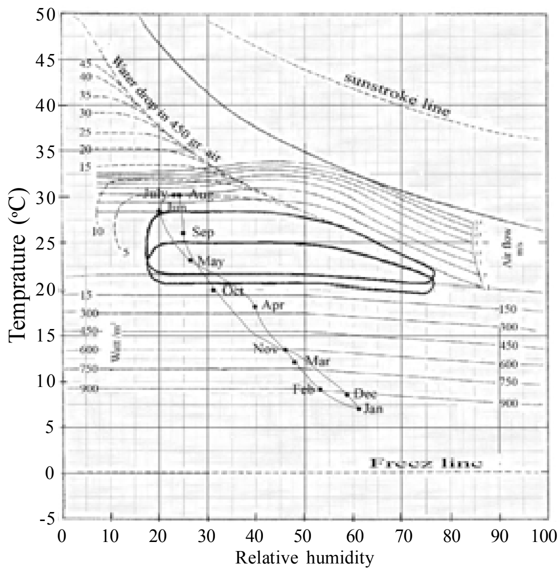

Fig. 3: Guni comfort climatic model average of daily bio-climatic condition for Present term

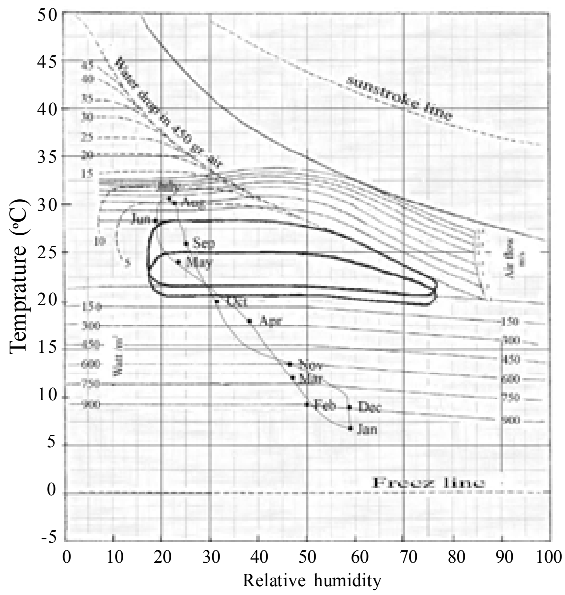

Fig. 4: Guni comfort climatic model average of daily bio-climatic condition for future term

30 drops of water in each 450 g of air together with airflow. January is also the farthest cold month from comfort region that requires 750 watt/m^2 heat-radiation energy to reach comfort.

B) In the first 11 year period, April has been in the comfort region and October is attached to it from the top, from bottom, the nearest month to the comfort region is November that in the second period, the situation has been altered in a way that October has moved upward and November entered the comfort region. These conditions were repeated for the third period.

C) In the fourth period, April and November is in comfort region as before. But April moved to right in comparison with previous periods. The important point is the movement of warm and cold months to the warmer areas of diagram. January required 750 watt/m^2 of heat-radiation energy to reach comfort, but in the recent periods, this amount has been decreased almost to 730 watt/m^2.

D) The fifth period shows a new situation in a way that November gets out of the comfort region and April moves to the end right of this region, October takes distance from the comfort region and March has been getting closer to that.

E) As it is shown in the diagram to forecast for 2017, the warm months will get drier in comparison with the fifth period, since they require more water drops to reach comfort, in a way that in the fifth period, just July requires 15 drops of water in each 450 g of air,but it is estimated that in 2017, this situation would be also for the months September, August, June and July.

Bio-climatic conditions in the cold hours of night (Figs. 8-10)

A) Long-term average of data shows that neither of the months is in the comfort region. But the months of July, August and June are the closest months to the comfort region accordingly. However, January, December and February are the farthest months from comfort region and they are in the limit of freezing line.

B) From the first to the third 11 year periods, the conditions are similar to the long-term average. But in the fourth period, the change in conditions has been in a way that the months of January, December and November get beyond freezing line, and July enters the comfort region. But in the fifth period, August also enters the comfort area and the months of January, December and

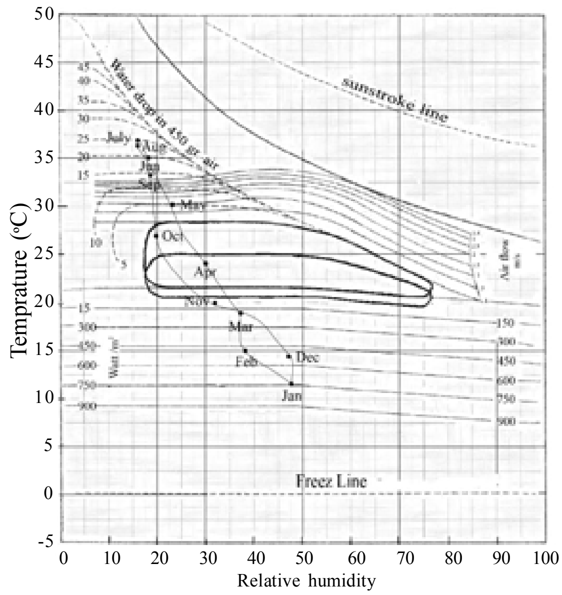

Fig. 5: Guni comfort climatic model for Bio-climatic conditions in the warm hours of day for past term

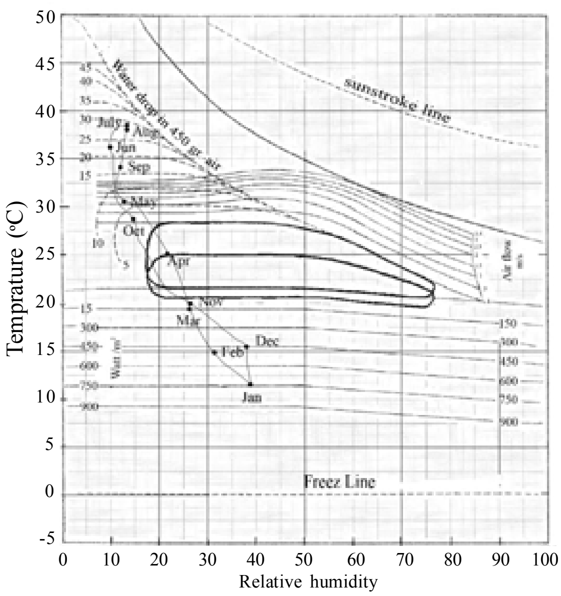

Fig. 6: Guni comfort climatic model for Bio-climatic conditions in the warm hours of day for present term

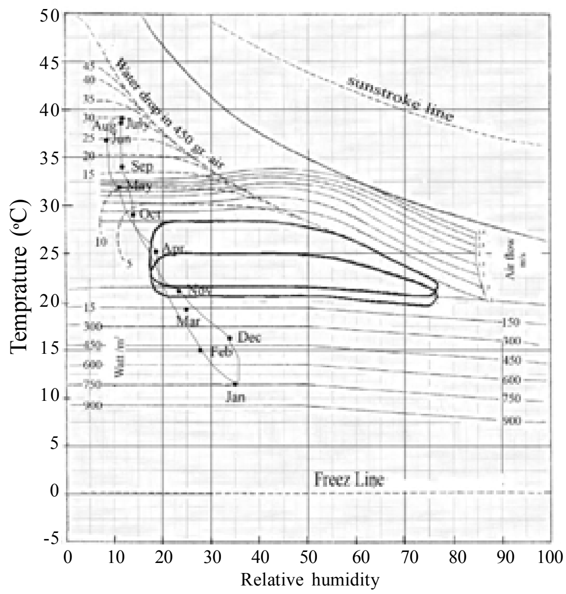

Fig. 7: Guni comfort climatic model for Bio-climatic conditions in the warm hours of day for future term

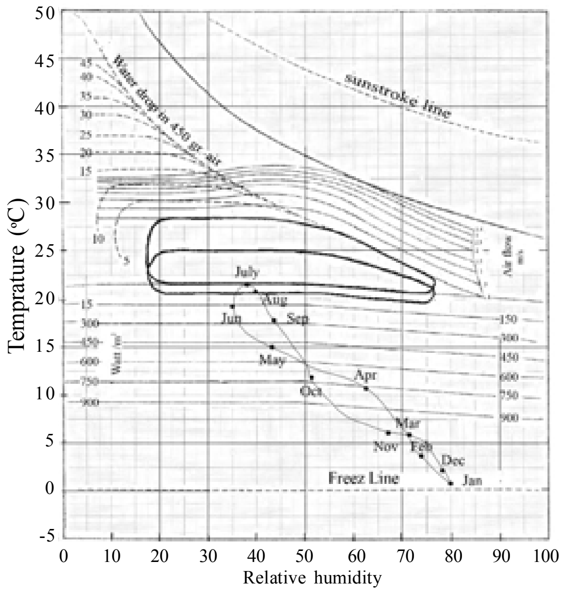

Fig. 9: Guni comfort climatic model for Bio-climatic conditions in the cold hours of night for present term

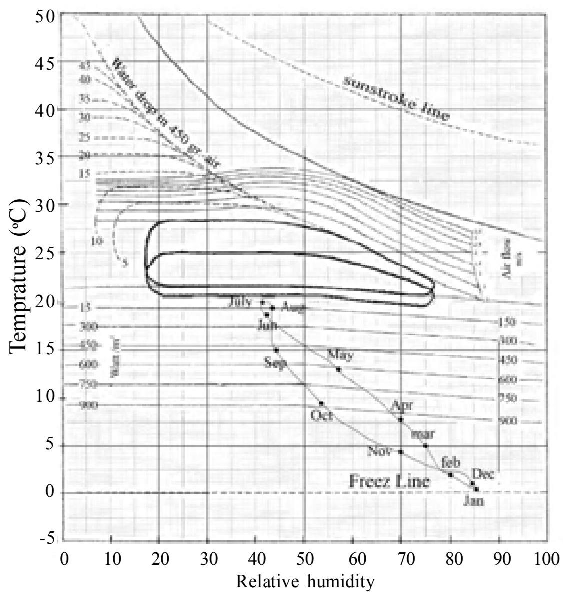

Fig. 8: Guni comfort climatic model for Bio-climatic conditions in the cold hours of night for past term

February take a little more distance from freezing line in comparison with pervious periods.

C) It is estimated that by 2017,minor change will be made in the cold months of the year. For example in November, the rate of humidity and temperature will be increased a little and this month will move a little toward the comfort region. September and May will have reverse conditions in comparison with the fifth period, in a way that it is expected that by 2017, September gets closer to the comfort region in comparison with May. June which get closer to the comfort region in comparison with the fifth period, but August and July will be also in the comfort region.

DISCUSSION

Average of Daily Bio-Climatic shows that in the first 11 year period, May, September and June are in comfort region, August and July are tangent to comfort region and other months are away from comfort region. But By estimating for 11 year period up to 2017, it is shown that the months of June, July and August are above comfort region, but it is expected that in future these months take some distance from each other in comparison with the present situation. But September and May are in the comfort region as before that the month of May will have a significant change than before and maybe in the next periods (the next 20 years), it will get out of comfort region and October substitutes it.

Bio-climatic conditions in the warm hours of day shows that in the first 11year period ,April has been in the comfort region and October is attached to it from the top, from below, the nearest month to the comfort region is November that in the second period, the situation has been altered in a way that October has moved upward and November entered comfort region that these conditions repeated for the third period. As it is shown in the diagram to forecast for 2017, the warm months will get drier in comparison with fifth period, since they require more water drop to reach comfort, in a way that in the fifth period, just July requires 15 drops of water in each 450 g of air, but it is estimated that in 2017, this situation is provided for September, August, June and July also.

Bio-climatic conditions in the cold hours of nigh Long-term average of data shows that neither of the months is in comfort region. But the months of July, August and June are the closest months to comfort region accordingly. However, January, December. and February. are the farthest months from comfort region and they are in the limit of freezing line. It is estimated that by 2017, a minor changes is made in the cold months of the year. For example in November, the rate of humidity and temperature is increased a little and this month moves a little to comfort region. September and May will have a reverse condition in comparison with the fifth period, in a way that it is expected that by 2017, September gets closer to comfort region in comparison with May. June also gets closer to comfort region in comparison with the fifth period, but August and July are also in comfort region.

In respect to evaluate the temperature sector for Shiraz station, increase and meaningful process for much to the months are observed; this manner is affected with global warming.

ACKNOWLEDGMENTS

This work was financially supported by the Islamic Azad University of Shiraz branch.The authors would like to thank very much Mrs.Jaladat for reviewing this manuscript. The authors also thank Dr.Mohammadnejad and Dr.Nasrabade for assistance in this project and their points of view.

REFERENCES

Alijani, B., (1993). A new approach to the application of water and meteorology in resources management and development of country, the role of climate in housing design. Geographical Research Seasonal., **35** (4):150–168.

Balafoutis, C., Papadimitriout, A. A., (1987). A Study of Climatic Stress and Physiological in Greece. International Journal of Climatology., **7**(3): 303-312 .

Bureau of Meteorology, Commonwealth of Australia, 2006. About theWBGT and apparent temperature indices ./http://www.bom.gov. au/info/thermal_strees/S (accessed 23.11.06).

Dear, R. J. DE., (1989).Diurnal and Seasonal variations in The Human Thermal Climatie of Singapore. Singapore Journal of Tropical Geography(SJTG)., **10**(2): 48-56.

Frank , F., (2005). Climate change impacts on building heating and cooling energy demandin Switzerland Energy and Buildings. Energy and Buildings., **37** (11): 1175-1185.

Geiger, R., (1965). The Climatic Near The Ground. Cambridge Mass: Harvard University Press.

Ghobadian, V., Feizmahdavi, M., (2001). climatic planning, theoretical principles and applied execution of energy in building, Tehran University Publication, Tehran .

Givoni, B., (1989). Urban design in different climates, World Meteorology Organization TD, No.366, Geneva.

Giveoni, B., (1989). Man, Climate and Architecture, John, Willy USA.

Hooshvar, Z., (1986). An Introduction to Iranian Geographical Medicine , Central Office of ACECR , Tehran.

Hooshvar, Z., (2002). Pathology of Iranian Geography, First Volume: Principles and Fundamentals, ACECR Publications , Mashhad.

Jendritzky, G., Maarouf, A., Fiala, D., Staiger, H., (2002). An update on the development of a universal thermal climate index. In: Proceedings of the 15th Conference on Biometeorology and Aerobiology and 16th ICB02, 27 October–1 November, Kansas City, AMS., 129–133.

Jendritzky, G., Maarouf, A., Staiger, H., (2001). Looking for a universal thermal climate index UTCI for outdoor applications. In: Windsor Conference on Thermal Standards, 5–8 April, Windsor, UK.

McGregor, G. R., Nieuwolt, S., (1998). Tropical Climatology, John Wiley and Sons, London, UK.

Miguel, G., A. P., Rubio, E., Fernández,E., Muñoz,V.G., (2002). Effect of passive techniques on interior temperature in small houses in the dry, hot climate of northwestern Mexico. Renewable Energy., **26** (1): 121-135.

Mochida, A., Lun, Y. F., (2008). Prediction of wind environment and thermal comfort at pedestrian level in urban area. Journal of Wind Engineering and Industrial Aerodynamics., In Press.

Steadman, R. G., (1984). Norms of apparent temperature in Australia. Aust. Meterol. Mag., **43**: 1–16.

Thompson, R. D., Allen, P., (1997). Applied Climatology, Principles and Practice, Rutledge.

Wang, Z., Yi Li, L., Wong, A. S. W., (2005). Simulation of clothing thermal comfort with fuzzy logic,Elsevier Ergonomics Book Series., **3**: 467-471.