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Trends of Outdoor Thermal Discomfort in Mymensingh: an Application of Thoms' Discomfort index

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Abstract

Thermal comfort is considered very important in aspects of risk assessment, summertime morbidity or in building designing. The present study applied Thomôs discomfort index (DI) to assess the trend of outdoor thermal discomfort in Mymensingh City during 2006-2015. It wasfound that December to February months was comparatively comfortable, DI values were typically <21 and therefore no people felt any discomfort in these months. On the other hand, under 50% population experienced discomfort during March and November months when discomfort valueswere ranged between 21- 24. From April to October months discomfort values varied from 25-27, which indicated thatover 50% population suffered from discomfort in this period. Though no extreme discomfort condition observed in Mymensingh city, the results revealed from June to September months most of the population suffered from severe discomfort in Mymensingh city due to the high air temperature, and high relative humidity.

Key words: Air temperature, Discomfort index, Outdoor environment, Thermal stresses

Introduction

Assessing outdoor thermal comfort is one of the vital issues of the climate control system (Bady, 2014). Thermal comfort referred to the condition in which the human mind expresses satisfaction to the ambient environment (Bady, 2014; Assael *et al.,* 2010; ISO, 1983; ASHRAE, 1966). Thermal stress severely affects an individualôs productivity and health (Epstein and Moran, 2006). Therefore, in the context of human health and the quality of urban climate, assessing thermal risk is considered very important (Polydoros and Cartais, 2014). Many researchers had tried to figure out the influences of climatic parameters on a humanhealth and human body heat adjustments system towards the ambient environment (Angouridakis and Makrogiannis, 1982). Human thermal comfort influenced by temperature, relative humidity, wind velocity, radiation (Angouridakis and Makrogiannis, 1982), dry bulb temperature, wet bulb temperature and by vapor pressure (Bhattacharya *et al.,* 2014). Sharma *et al.* (2015) stated that air temperature, the condition of air, and humidity combinedly influenced human body physiology. Over a century, many attempts have been taken off in constructing an index to explain heat stress properly (Epstein and Moran, 2006). Many indices were established based on-air temperature, relative humidity, and wind speed (Becker *et al.,* 2003; Matzarakis and Mayer, 1996; ISO, 1983; Steadman, 1971; Thom, 1959). Discomfort index (DI) is one of the indices based on basic environmental parameters air temperature and relative humidity (Yousif and Tahir, 2013; Epstein and Moran, 2006) and expresses the combined contribution of air temperature and relative humidity on human thermal comfort (Stathopoulou *et al.,* 2005). Bangladeshôs climate is characterized as sub-tropical monsoon climate, during the summer periods mean temperature varies between 23-30C, high amount of humidity observed during June to September (Khatun *et al.,* 2016). Researchers stated people lives in a big city have a great risk of morbidity and mortality due to the high amount of temperature (Nastos and Matzarakis, 2006). Intergovernmental panel on climate change (IPCC) stated that in the twentieth century the average global air temperature increased nearly 0.76 C, and the trend of linear warming was found double in the last 50 years in comparing to the last 100 years (Potchter and Ben-Shalom, 2013; IPCC, 2007). Global warming is one of the major concerns for the recent years in tropical countries. Alcoforado and Andrade (2008) stated that health of people will be impacted more in the urban areas because of the global warming. Global and regional warming will exasperate the urban warming during summertime (Fujibe, 2009) consequently the air temperature will arise extremely, and this condition might be sustained for a long while (Golden, 2004). Mymensingh is one of the biggest and populated cities of Bangladesh, due to the climatic characteristics is assumed that people sufferfrom discomfort and heat stress in that city. On regional and demographic context, the present study has found some significance to evaluate the trend of discomfort index of Mymensingh city.

Study area and demography

Mymensingh city is located at 24.7500°N and 90.4167°E, with an area of 380.72 sq.km. In 2011 the total urban population of Mymensingh was 389,918 (Zila Report: Mymensingh, 2015).

Methods

Temperature and Relative Humidity data were collected from Bangladesh Space Research and Remote Sensing Organization (SPARRSO). Data were analyzed by Microsoft Excel. Discomfort index was calculated and interpreted by the following manners of Thomsô discomfort index (Yousif and Tahir, 2013; Assael *et al.,* 2010).

DI= T-(0.55-0.0055RH) (T-14.5)

Where DI= Discomfort Index
T= Mean air temperature in °C
RH= Average relative humidity (%)

Table1. Thomôs discomfort states (Yousif and Tahir, 2013).

Condition	DIrange
No Discomfort	<21
Under 50% of Population feels discomfort	21-24
Over 50% of Population feels discomfort	25-27
Most of the Population feels discomfort	28-29
Everyone feels stress	30-32
State of medical emergency	>32

Results

Decadal average mean air temperature and average relative humidity from 2006 to 2015.

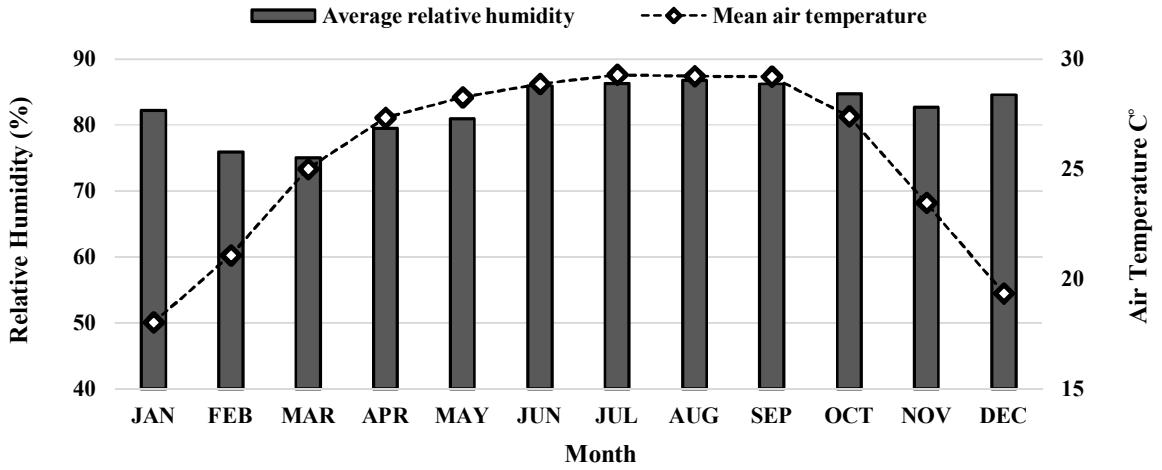

Fig. 1. The trend of decadal mean air temperature and average relative humidity (2006-2015).

Figure1 represents the trend of decadal average mean air temperature (Cę) and average relative humidity (%) between 2006 and 2015 in Mymensingh city. The minimum value of the average relative humidity was found 75% in March, on the other hand, the maximum value was found at 86.81% in August. It could be noticed that the relative humidity of air fluctuated over the times and the peak values (>85%) were found during June to September. From the figure1,it could be noticed air temperature varies during winter to summer. The maximum value attained in July 29.29 Cę and the minimum value found in January 18.02 Cę. Therefore, it could be considered July was the warmest and January was the coldest months. The temperature started to fall gradually from October to February and next to January, and it became rises from February to June. During July to September temperature was tended to be higher than any other months. In this respective monthôs air temperature typically found > 28.25Cę, hence the average air temperature was 28.96 Cę in these periods. On the contrary during winter periods (November ï February) temperature typically found between the range 18Cę - 24Cę. A positive relationship between relative humidity and air temperature has been observed during June to September, both climatic variables tended to be higher in the respective months in Mymensingh city.

The trend of discomfort index in Mymensingh

Table 2. Discomfort index of Mymensingh from 2006-2015

Month	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
January	17.72	16.94	17.93	18.75	17.51	16.32	19.18	16.88	18.76	18.43
February	22.7	19.91	18.67	20.94	20.32	20.31	19.71	20.85	18.73	19.91
March	23.72	22.15	23.79	23.5	24.65	23.3	23.72	24.13	23.58	22.88
April	25.28	25.06	26.16	26.69	26.54	25.34	25.3	25.86	26.73	25.38
May	26.68	27.4	26.83	26.73	26.86	26.31	27.08	26.07	27.25	26.57
June	27.45	27.37	27.34	28.03	27.6	27.8	27.37	28.3	28.14	27.94
July	28.2	27.61	27.74	27.92	28.4	27.81	28.04	28.23	28.64	28.77
August	28.13	28.19	27.85	27.98	28.2	27.7	28.3	27.81	28.63	28.57
September	27.73	27.85	28.12	28	27.76	27.86	28.13	28.11	27.89	29.13
October	26.74	26.22	26.12	26.41	26.86	26.82	26.29	26.19	25.64	25.82
November	22.79	23.27	22.31	23.14	23.35	21.94	21.38	22	22.69	22.61
December	19.42	19.12	20.16	18.89	19.1	18.63	17.8	18.4	18.9	18.36

Table 2. represents the values ofdiscomfort index (DI) from 2006 to 2015 in Mymensingh city. From the table, it has been observed that DI varies due to seasons. From December to February (winter) the DI values were typically found within the comfort range <21. In these period temperature tended to be lower in comparing to other months, and no one felt any discomfort during these periods. On the other hand, the DI rangewas found between 21-24 in March and November months. Therefore under 50% population suffered from discomfort during March and November months in Mymensingh. With few exceptions, in most of the years, the DI range foundbetween 25 to 27 during April to October months. In these months highest and lowest DI values were found at 25.06 and 28.77 respectively, during those months over 50% population suffered from discomfort in Mymensingh city. Moreover, some extreme discomfort values (Ó28) were also foundfrom June to September in several observing years except for 2011. During this months both temperature and relative humidity tended to be higher, and therefore it also affected the DI ranges of the respective months. According to Thomsô standard, most of the population suffered from discomfort during these periods. So most discomfort periods in Mymensingh were June to September.

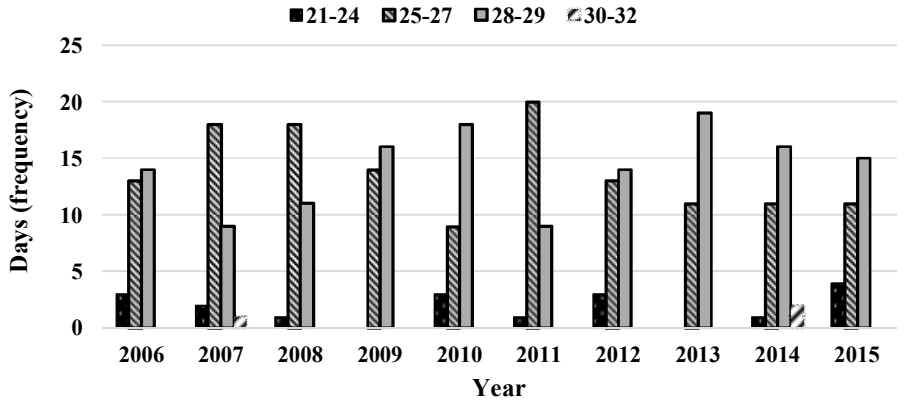

Fig. 2. The frequency of differentdiscomfort conditionsof June months during 2006-2015.

Figure 2. represents the frequenciesof different discomfort conditions occurred during June months between 2006-2015. Except for some variation, it seems thatin the maximum timesthe DI ranges were between 25-27, and between 28-29.The discomfort range 25-27 were observed in maximum days of June months during years 2007 (18 days), 2008 (18 days) and in 2011 (20 days). On the other hand, discomfort range 28-29 has been observed maximum days in June 2006 (14 days), 2009 (16 days), 2010 (18 days), 2012 (14 days), 2013 (19 days), 2014 (16 days), and in June 2015 (15 days) respectively. It could be noticed that in recent years from 2012-2015 during June maximum days the range was found between 28-29, which indicates most of the population suffered from discomfort in recent years during June months. A very few days hardly found in June 2007 (1 day) and 2014 (2 days) when the discomfort range found between 30-

32, where everyone felt discomfort in Mymensingh city.

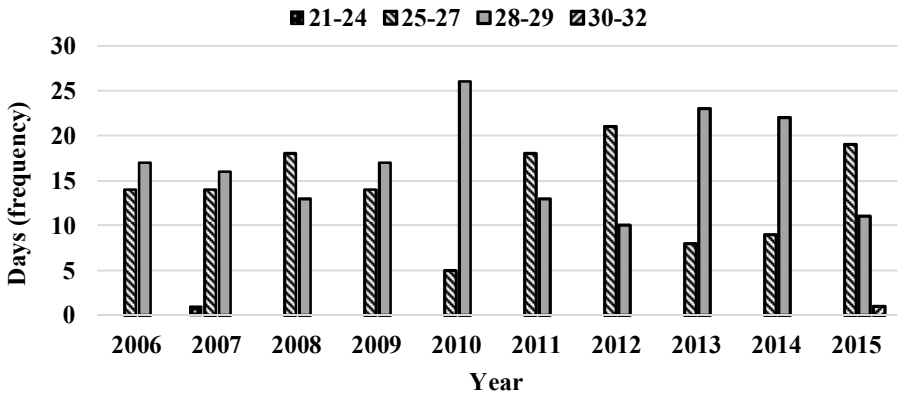

Fig. 3. The frequency of different discomfort conditions of July months during 2006-2015.

Figure 3 represents the frequencies of different discomfort conditions occurred during July months between 2006-2015. Except for some variation majority days in July months in the respective years, discomfort ranges (DI) were found either between 28-29 or between 25-27. Over 50% population suffered from discomfort in maximum days during July months in 2008 (18 days), 2011 (18 days), 2012 (21 days) and in 2015 (19 days) in Mymensingh city.In these respective months discomfort range were found between 25-27. On the contrary, most of the people suffered from discomfort in Mymensingh cityduring July months in 2006 (17 days), 2007 (16 days), 2009 (17 days), 2010 (26 days), 2012 (23 days), and in 2014 (22 days).

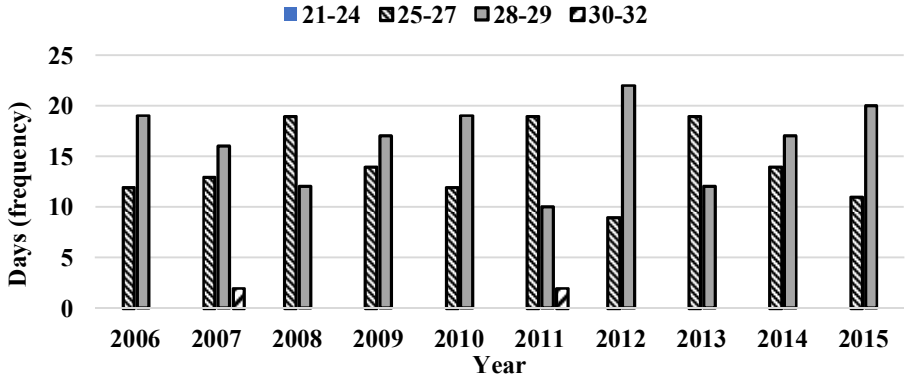

Fig. 4. The frequency of different discomfort conditions of August months during 2006-2015.

Figure 4 represents the frequencies of different discomfort conditions during August months from 2006 to 2015.Discomfort range (DI) 25-27 was found maximum days during August months in 2008 (19 days), 2011 (19 days), and in 2013 (19 days) when over 50% population suffered from discomfort. On the other hand, discomfort range 28-29 were found in maximum days during August in 2006 (19 days), 2007 (16 days), 2009 (19 days), 2012 (22 days), 2014 (17 days), and in 2015 (20 days). In these respective months, most of the population suffered from discomfort in Mymensingh city. A very few days were found in August 2007 and 2011 when discomfort rangewas found between 30-32 and everyone felt stress in Mymensingh city in these days.

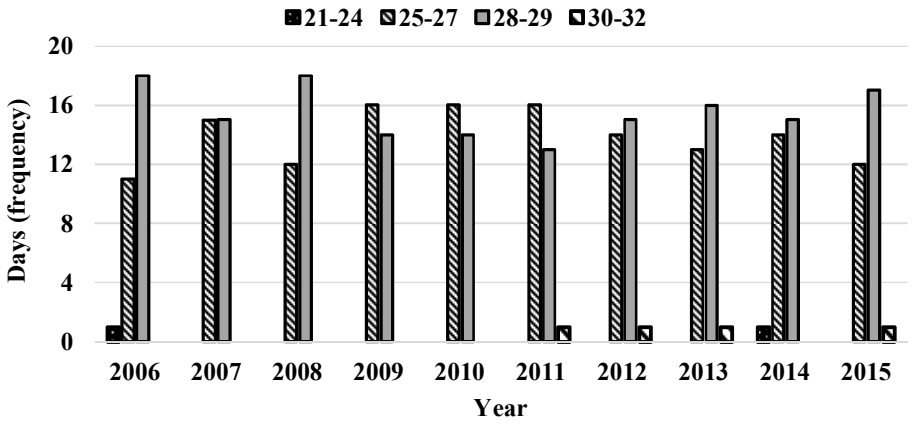

Fig. 5. The frequency of different discomfort conditions of September months during 2006-2015.

Figure 5 represents the frequencies of different discomfort conditions of September months from 2006 to 2015. Except for some variation it has been foundin maximum days the DI values were ranged between either 25-27 or 28-29. Discomfort range 25-27 were found in 16 several days during September months in 2009, 2010, and in 2011. In these periods over 50% population suffered from discomfort in Mymensingh city. On the other hand, discomfort range 28-29 were found in maximum in 2006 (18 days), 2008 (18 days), 2012 (15 days), 2013 (16 days), 2014 (15 days) and in 2015 (17 days). In these periods most of the population suffered from discomfort in Mymensingh city. From 2011 to 2015 (except for 2014) in September monthsa very few days were found when everyone felt stress in Mymensingh city.

Conclusions

The primary aim of the present study was to assess the trend of thermal discomfort in Mymensingh city, therefore this study examined the secondary data of daily dry bulb air temperature and relative humidity from 2005-2016 to analyses Thomôs discomfort index. Results revealed that no people felt any discomfort during winter (December to February). On the contrary under 50% and over 50% population experienced discomfort during March and November and from April to October months respectively. Moreover, thestudy also found during June to September months most of the population suffered from discomfort in Mymensingh city. The study concluded with that people of Mymensingh city need to be aware of comfortable clothing and adaptive measures during the June to September in order to avoid outdoor thermal discomfort.

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