ASSESSMENT Of OUTDOOR THERMAL HUMAN COMFORT AT FIVE MAJOR CITIES OVER EGYPT

Sally Mahmoud [1], S. M. Robaa [2], M. M Abdel Wahab [2]

[1] *Egyptian Meteorological Authority, Cairo, Egypt*
[2] *Astronomy, Space Sciences and Meteorology Department, Faculty of Science, Cairo University, P.O. 12613 Giza, Egypt.*

ABSTRACT

People all over the world are facing the reality of climate change which is a major risk to development outcomes. The aim of this research paper is to study the human thermal comfort over five Egyptians cities. The observational and solar radiation data (from 1982 to 2020) gathered from Climatic Research Unit Timeseries (CRU TS) and NASA Prediction of Worldwide Energy Resources (POWER) respectively. The result show that, most of the population suffer from heat stress during July and August at all study area. the city of Aswan is the highest in the values of thermal discomfort, which is located in the south, the thermal discomfort increases the further south we go in Egypt. Analyzing human thermal comfort and comparing it with solar radiation data will help us to give a clear picture of the impact of climatic changes on Egypt.

Keyword: - *Human Comfort Evaluation, DI, UTCI, Egypt*

1. INTRODUCTION

After the spring season ends, months June to September is generally known as summer months which are stressful especially for the outdoor activities. Heat linked exhaustion and heat stroke are dangers to people not accustomed to the physiological heat stress of hot climate. The magnitude of heat stress depends on a number of factors - ambient air temperature, relative humidity, global radiation and clothing insolation.
Nowadays, many studies have focused on studying the bioclimate in external conditions and in different areas [1-3]. Various studies have been conducted in several countries and focused on the relationship between thermal comfort and climate [4-6]. There are more than fifty-five indices used to assess thermal comfort and health hazards. The important factor determining human discomfort is the thermal component of environmental conditions and was determined by a large number of indices using ambient air temperature, wind speed and relative humidity [7-14]. In the present paper an attempt is made to get an idea about the degree of heat stress during months from 1982 to 2020 using estimates of different human comfort index from the available data set.

2. MATERIAL AND METHODS

Egypt is transcontinental country located in North Africa, the Middle East, and Asia, making its geography very interesting (30° 06' N and 31° 25' E). Dry bulb temperature, wet bulb temperature, relative humidity, vapor pressure and solar radiation data for the period 1982 to 2020 of five selected sites-Cairo (30.25°, 31.25°), Alexandria (31.25°, 29.75°), Ismailia (30.75°, 32.25°), El Minya (28.25°, 30.75°), and Aswan (24.25°, 32.75°) are collected from Climatic Research Unit Timeseries (CRU TS) and NASA Prediction of Worldwide Energy Resources (POWER) as seen in Figure 1.

Fig -1: Location of study area

As shown in Table 1, thermal comfort indexes used in this study are: Thom's Discomfort Index (DI) method which used to indicate the level of thermal comfort in selected study area, and the Universal Thermal Climate Index (UTCI) is a human biometeorology parameter that is used to evaluate the relationships between outdoor environment and human well-being [15].

Table -1: Discomfort scale of two selected human thermal comfort index [16-17].

UTCI (°C)	Thermal Stress	DI (°C)	Thermal Stress
+9 to 0	Slight cold stress	15 – 18	Relatively comfort
+9 to +26	No thermal stress	18 – 21	No discomfort feeling
+26 to +32	Moderate heat stress	21 – 24	< 50% of the total population feels discomfort
+32 to +38	Strong heat stress	25 – 27	> 50% of the total population feels discomfort
+38 to +46	Very strong heat stress	28 – 29	Most of the population feels discomfort
above +46	Extreme heat stress	above +32	State of medical emergency

3. RESULT AND DISCUSSION

Combine of highest air temperature together with highest relative humidity produces rising thermal discomfort, and vice versa. As illustrated on chart 1, in December, January, February, Mars and April, the DI value indicated that relatively discomfort, while May and June less than 50% of the total population perceived warm discomfort nearly in the five cities. More than 50% of the total population suffered from thermal discomfort during July and August at all study area. Aswan city has the highest value in thermal discomfort compared to other cities.

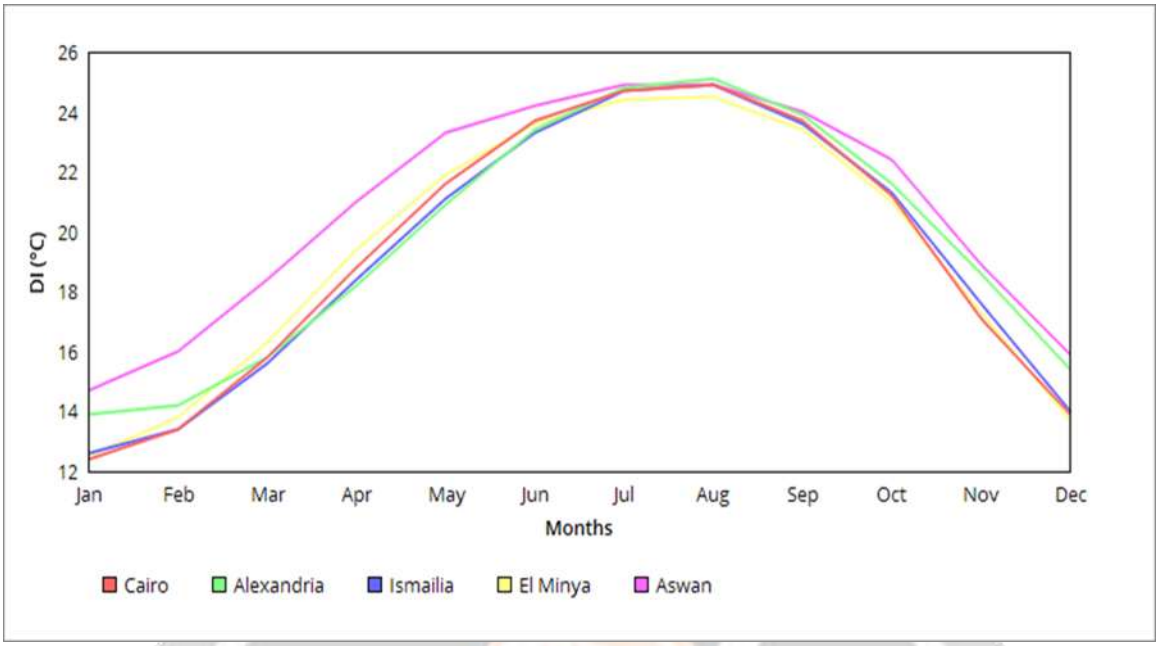

Chart -1: Average monthly DI (ºC) at stations for the period 1982-2020.

As shown in Chart 2, different grades of no thermal stress (9 > UTCI > 26 °C) occurred mostly all the year months except from June to September with (26 > UTCI > 32 °C) indicating at least Moderate heat stress, while the month of May in Aswan considered as moderate heat stress.

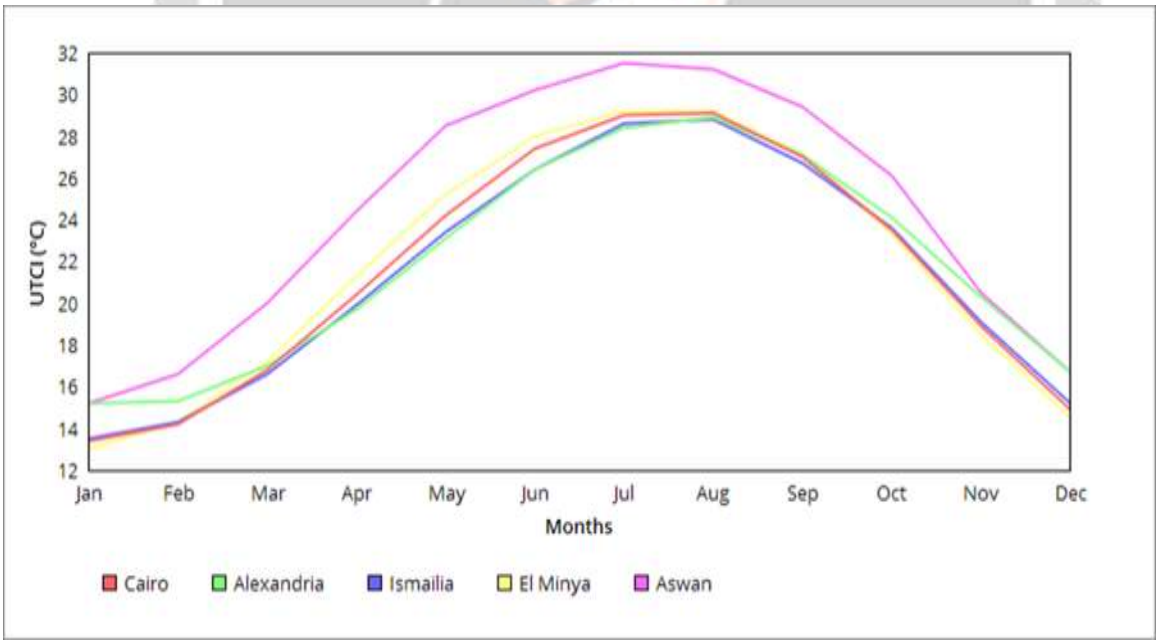

Chart -2: Average monthly UTCI (ºC) at stations for the period 1982-2020.

As shown in Table 2, a high albedo surface reflects a large amount of solar energy up into the atmosphere. Albedo varies with the surface, Alexandria is a coastal city with albedo 0.05, while albedo shows 0.36 in Ismailia which Characterized by fertile soil and vegetation.

Table -2: Descriptive statistics of average meteorological and solar radiation parameters from 1982 to 2020 over Egypt.

Cities	Surface Albedo	Surface UVA Irradiance (w/m2)	Surface UVB Irradiance (w/m2)	Maximum Temperature (°C)
Cairo	0.2	13.1	0.3	43.6
Alexandria	0.05	12.8	0.29	40.5
Ismailia	0.36	13.7	0.32	42.5
El Minya	0.35	14.1	0.33	44.8
Aswan	0.35	15.1	0.38	47.2

As we note in the table also, Ultraviolet A (UVA) (has a longer wavelength) which associated with skin aging and Ultraviolet B (UVB) (has a shorter wavelength) and is associated with skin burning. UV levels vary mainly with the height of the sun in the sky and in mid-latitudes are highest during the summer months during the 5-hour period around solar noon. We find that the cities with the highest value in UV rays are Aswan, followed by Al Minya, where the values of UV A and B rays increase as we go from north to south over Egypt.

Analyzing human thermal comfort and comparing it with solar radiation data will help us to give a clear picture of the impact of climatic changes on Egypt.

4. CONCLUSIONS

In general, humidity is affected by air temperature, as the higher the air temperature, the more moisture it can hold. Therefore, the humidity varies with the seasons of the year. The thermal human comfort indexes applied in this study are nearly similar in almost all stations and representative of the thermal sensations. The most commonly meteorological variables used is air temperature and relative humidity, it is easy to use and most people can relate to it. Albedo varies with the surface, studying the surface albedo of Ismailia indicated a change in the surface feature and characteristic of this city. also, UV A and B rays whose values increase according to the seasons of the year, differing in summer from in winter.

Relative humidity and temperature play an important role in human thermal comfort, especially when they meet with high values. Egypt is one of the countries that are vulnerable to climate change, which has become an obsession and warning of danger to the whole world.

5. REFERENCES

[1]. Evans G.W. Environmental Stress. Cambridge University Press. 1982.

[2]. Nikolopoulou, M.: Outdoor Comfort. – In: Steemers, K., Steane, M. A. (eds.) Architecture and Variety: Environmental Perspectives. Spon Press, London. 2004.

[3]. Geletič, J., Lehnert, M., Savić, S., Milošević, D. Modelled spatiotemporal variability of outdoor thermal comfort in local climate zones of the city of Brno, Czech Republic. – Science of the Total Environment. 2018; 624: 385-395.

[4]. Thorsson, S., Honjo, T., Lindberg, F., Eliasson, I., Lim, E. M. Thermal comfort and outdoor activity in Japanese urban public places. – Environment and Behavior. 2007; 39: 660-684.

[5]. Kántor, N., Égerházi, L., Unger, J. Subjective estimation of thermal environment in recreational urban spaces—Part 1: Investigations in Szeged, Hungary. – International Journal of Biometeorology. 2012a; 56(6): 1075-1088.

[6]. Kántor, N., Unger, J., Gulyás, Á. Subjective estimations of thermal environment in recreational urban spaces—Part 2: International comparison. International Journal of Biometeorology.2012b; 56: 1089-1101.

[7]. Steadman, R.G. Indices of wind chill. J. Apple. Meteorol. 1971; 10:674-683.
[8]. Oliver, J.E. Climatology, Selected Applications, Winston and Sons, London. 1981; pp; 189-191.
[9]. Suping Z, Guanglin M, Yanwen W & JI L. Study of the relationships between weather conditions and the marathon race. International Journal of Biometeorology. 1992; 36(2): 63–68.
[10]. Matzarakis A, Mayer H. Another kind of environmental stress: thermal stress. Newsletters no.18, 7-10. WHO collaborating center for air quality management and air pollution control. 1996.
[11]. Becker S, Potchter O, and Yaakov. Calculated and observed human Thermal sensation in an extremely hot and dry climate. Energy and building. 2003; 35,747-756.
[12]. ISO 7730: Moderate thermal environments-determination of the PVI and PPD indices and specification of the conditions of thermal comfort. International organization of standardization, Geneva. Israel-Geography. U.S. Library of Congress. Retrieved 8 April 2008.
[13]. Blazejczyk, K., Epstein, Y., Jendritzky, G., Staiger, H., Tinz, B. Comparison of UTCI to selected thermal indices. International journal of biometeorology. 2012; 56(3): 515-535.
[14]. Bröde, P., Fiala, D., Błażejczyk, K., Holmér, I., Jendritzky, G., Kampmann, B., Havenith, G.Deriving the operational procedure for the Universal Thermal Climate Index (UTCI). International journal of biometeorology. 2012; 56(3): 481-494.
[15]. Epstein Y., Moran D.S. 2006. Thermal Comfort and the Heat Stress Indices. Industrial Health. 2006; 44(3), 388–398.
[16]. Thom, E.C. The discomfort indexes. Weather wise. 1959; 12:57-60.
[17]. Ketterer, C., Matzarakis, A. Development and application of assessment methods for thermal bioclimate conditions in Stuttgart. – ICUC8, 8th International Conference on Urban Climates, 6th-10th August, UCD, Dublin Ireland. 2012.