The effect of the characteristics formation of urban open space on thermal comfort for pedestrian

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Abstract: Urban spaces are prominent urban configurations for the cities, its important came from its role on encourage human daily social communication and activities. During last decades several studies searched on achieving thermal comfort in cities and urban spaces, the importance of providing thermal comfort at the urban scale in the city had emerged because of its importance to pedestrian daily activities. However, the study of the characteristics formation of open spaces and their effect on providing thermal comfort in the city of Baghdad as an example of hot dry areas was not addressed previously, and this is what represents the research problem. This research aims to analyze the reality of the situation of (Al Ghurery Square) in Al Rashid Street and study the effect of its formal properties on thermal comfort Using Envi-Met Software. The results showed that the Predicted mean vote, Mean radiant temperature near the arcade surrounding the semicircular building achieved better results as compare to street space. While the wind speeds in the street space was higher.

1. Introduction
Urban spaces are the most prominent manifestations in cities, it include all the physical characteristics of buildings that surround the urban space, the psychological and culture formation for the peoples of cities [1]. Urban space defined as a three-dimensional framework that had the characteristic of containment. It contains things, people and activities through its three dimensions, which is every space between buildings in the city. It also has the characteristic of evolution over time, whether urban or human development [2]. It also defined as those spaces that are built or not built between buildings in the city, and each space has a unique use and personality, each space has a shape, size, dimensions, material, color, texture, other properties and elements with features that suit the function for which this space was prepared [3]. Many literatures studied outdoor thermal comfort in cities and urban spaces [4]. (Ali. et al.2017) The study aimed to understand the conditions of thermal comfort in open places during hot dry conditions. The study was conducted in Bhopal (the capital city of Madhya Pradesh state in central India) and this city is characterized by a tropical savanna climate. Field surveys of this study were conducted in three types of urban open spaces, namely: green gardens, lake facades and open corridors of a new market located in the city center. With regard to the size of samples approved in this study, (80 persons) were identified from the respondents. The thermal comfort condition for the three outdoor spaces was determined based on:
objective measurement and subjective assessment, which was represented in the work of a questionnaire on human responses. According to the comprehensive assessment of the thermal conditions of the selected areas, green parks were cooler than other environments (lake facades and market corridors). In the current study of green gardens in the tropical climate, it seemed that TMRT and PET are closely related (with the tree cover), as the tree cover in the gardens reduces TMRT by about (0.7°C) and lowers the PET by (0.8), which indicates the importance of vegetation in providing thermal comfort in a garden environment in cities with a tropical climate. What is interesting in this study is its indication that the thermal sensitivity analysis of respondents shows that green and water environments were sensed as (warm) and (warm to hot) respectively, and built environments (market corridors) were sensed to be (hot). However, respondents rated green environments as having a positive thermal effect on warm summer days. Whereas, although the estimated comfort level in all locations was (hot), respondents rated green environments (gardens) as (comfortable), water environments (comfortable to slightly uncomfortable) and built (market) environment as (uncomfortable) despite from their feeling that these external spaces (warm to hot) [5].

While (Lam. et al. 2005) examined the atmospheric environment (air quality), acoustic environment (noise levels) and heavy metal pollution (dust-related) in urban parks and open spaces in Hong Kong, which are considered to be cities with high density. Where the study aimed to determine: the extent of the urban gardens and open spaces to improve the urban environment by comparing the gardens environment with the surrounding environment, as well as health risks that threaten the visitors of Gardens and the factors that constitute the urban gardens environment. In order to achieve these goals, a comprehensive program of measurement and modeling (using the computer) was implemented in urban parks and open spaces in Hong Kong to obtain accurate environmental data for comparison with the environmental data for the wider surrounding areas. The results of the study indicate that the ability of urban parks and open spaces in Hong Kong (with high density), to improve the air environment (air quality) and acoustic environment (noise levels) are relatively limited due to the small size of these spaces and their local characteristics and at the same time their proximity to highways. In doing so, it does not support the long-standing belief that urban gardens can contribute a lot to improving the urban environment in cities with high densities. Despite these observations, the study also indicated that visitors to urban parks in Hong Kong are generally satisfied with the air conditions and noise level and most of them go to parks and open spaces to relax and communicate with other people. This means that urban gardens may have a role to play in enhancing the quality of urban life as their contribution to people's social [6]. (pezzuto.et al. 2004) aimed to assess the effect of the urban form on the climatic conditions of the urban open spaces in the city of Campinas, Brazil. The city of Campinas is located in the southwestern region in the state of Sao Paulo. This city is characterized by various configurations and a variety of land uses. In this study, data were collected to obtain the meteorological variables (temperature) in an open urban area in the city. The temperature measurements were carried out in this study at nine fixed points distributed along the chosen area. Then the data collected in these nine points were compared with those in the meteorological station of the Agricultural Research Center, which is located outside the urban center. The study, when analyzing the heat island phenomenon (UHI), indicated its strong relationship to urbanization, as areas with high construction and high population density offer greater thermal islands. The study also concluded that the urban area temperature was higher than that of the meteorological station, which proves the impact of urbanization on the local climate. Where it showed that the climate in cities suffers from the effects of the complex group of urban structure, namely: the engineering characteristics of buildings, the characteristics
of building materials, the density of the built-up area, land uses, building heights, street direction and width, subdivision, the effects of gardens and other green areas [7]. (Tukoglu 2014) determined the characteristics of the open urban area. Where Galatasaray Square was chosen in Turkey as a research area because its location - Istiklal Street - is one of the main features of the city's image and its different characteristics that separate it from other areas of the city. In this study, the main criteria that represented the research field were identified: identity, transport, social interaction, participation, safety and security, land use, gravity, user profile, natural space, and economy. So Galatasaray Square users were noticed. And collect data that includes classic analysis as a research method, through video recordings and urban analysis, according to the specified criteria. The study showed that the research area already had a strong identity. The study also indicated that it is a place where all groups of people interact in some way due to the high population that uses the area as an attractive road or as a transitional area [8]. This research problem that there was no obvious study of the characteristics of the formation of open spaces and their effect on providing thermal comfort in the city of Baghdad as an example of hot dry areas.

2. Outdoor thermal comfort

Thermal comfort defined as "a state of mind, which expresses satisfaction with the thermal environment"[9]. It also defined a according to the psychological and personal dimension by describing comfort, it relates comfort to energy gains and losses by expressing satisfaction when heat flows to and from the human body in equilibrium. This is accomplished when body data, which is the average sweat and/or base temperature and skin temperature, are within a range of comfort. Human physiological regulations are partly subject to this data [10]. Compared to the internal environment, the thermal equilibrium of the body is rarely in a constant state in the external environment. It is known that physical and mental performance break down when the human body is very warm. Additionally, at extremely high temperatures, heat stress may cause heat-related illnesses [11]. In addition, the level of outdoor activity tends to contrast more inside, usually from brisk walking to sitting. Seasonal climate changes also determine the type of clothing people wear outside. Moreover, people's physical adaptation to an environment can be done by adjusting how they dress and move, for example walking faster when it's cold and slow when it's warm. Outdoors, the environment is more dynamic and complex, so the psychological factors are likely to be greater. A number of studies have shown that the outdoor spaces have a wider comfort zone than the interior [12]. Fanger created a model of thermal comfort based on equations derived from human-controlled physical assessments in which environmental parameters are defined, such as: air temperature, radiant temperature, relative humidity, air velocity, and atmospheric pressure; and human characteristics, for Example: individual metabolic rate, level of clothing, and type of physical activity. The principle of this model is based on the fact that the human body tends to establish a thermal equilibrium with the environment, which means that heat is gained or lost in its achievement. The PMV index ranges from: -3 to +3 according to ISO 7730.

3. Methodology

Al-Ghurery Square, in the city of Baghdad, was chosen as a research sample. It on al-Rusafa side of the city of Baghdad, Location at (Al-Rasheed Street) is one of the main features of the city's image and its different characteristics that separate it from other squares in the city. Where Al Ghurery Square is a vital transitional zone provide opportunities for communication and social interaction between people. Being located in one of the most important and oldest historical and commercial hubs in the city of Baghdad,
which is (Al-Rashid Street), completed during the era of the Ottomans in 1910 AD. Al-Ghurery Square space is characterized by different configurations and various land use. The heights of the buildings surrounding the square range between (2-4) floors and commercial shops occupy the (Ground floor) of most of these buildings. As for the other floors, they are stores or offices. The building (semicircular) surrounding the urban space of the square contains a portico and columns along the facade, the height of the column (9 m) , its dimensions (40 * 40 cm) . The distance between the columns and wall of the building (3 m), the distance between the columns and the street (Al-Rasheed Street) (25 m). As for the surface materials, they are (asphalt), sidewalks (concrete), and the floor of the square contains (a small green area with some trees and plants). Buildings materials are bricks. The specific simulation program for measuring and analyzing the results of the effects of local climate and thermal comfort is (Envi-met v4), a three-dimensional computer program that simulates small climatic conditions in urban environments and can be used to evaluate several aspects for the purpose of conducting environmental simulations, predicting climate changes within the urban environment. The model was simulated in the program and then environmental analysis in the summer of (2019). The meteorological data were as follows: maximum temperature (45) and minimum (26) and northwest wind direction (315 degrees from north), wind speed (2.5 m / s). Simulation was conducted on (fourteenth) of June and (nineteenth) of July for an hour on the day (12-1 noon) and it represents the peak hour. Where the scenario was designed from the model with the dimensions of the grid (75 * 55 * 9) and accuracy (1 m * 1 m * 1 m) the model rotates from the north of the grid (38.2 degrees). The urban space of the square is divided into tested selective (five) points, which are (A, B, C, D, E), where point A is the closest to the arcade surrounding the semicircular, followed consequently by the rest of the points towards Al-Rashid Street as shown in Figure 1.

Figure 1. The selected research sample Al-Ghurry Square, with selective tested points

4. Results and discussion

4.1 Predicted mean vote
The simulation results in Appendix A showed that the average PMV in (June) in point A was (1.82 to 2 ), in point B was (2 to 2.17), in point C was (2.17 to 2.34), in point D was (2.34 to 2.52), in point E was (above 2.52 ). Where the difference in the average PMV between point A, and point E was (0.7). Results showed that in (July), point A (1.91 to 2.09), in point B (2.09 to 2.27), in point C (2.27 to 2.46), in point D
(2.46 to 2.64), in point E (above 2.64). Where the difference in the average PMV between point A and point E was (0.73).

4.2 Mean radiant temperature
The simulation results in Appendix A showed that the average (Tmrt) in (June) in point A was (24.11 to 24.99), in point B was (24.99 to 25.86), in point C was (25.86 to 26.73), in point D was (26.73 to 27.6), in point E was (27.6 to 28.47). Where the difference in the average (Tmrt) between point A, and point E was (4.36 C). Results showed in (July), point A (24.68 to 25.57), in point B (25.57 to 26.45), in point C (26.45 to 27.33), in point D (27.33 to 28.22), in point E (28.22 to 29.10). Where the difference in the average (Tmrt) between point A, and point E was (4.42 C).

4.3 Wind speed
The simulation results in Appendix A showed that the average wind speed in both (June and July) in point A was (0.77 to 1.53 m/s), in point B was (1.53 to 2.3 m/s), in point C was (2.3 to 3.06 m/s), in point D was (3.06 to 3.83 m/s), in point E was (3.83 to 4.6 m/s). Where the difference in the average wind speed between point A, and point E was (3.83 m/s) for both months.

4.4 Air temperature
The simulation results in Appendix A showed that all points in (June) were equal to (33.24 C). And in (July) were equal to (33.62 C). They are no differences in the values for all points in the open space.

4.5 Relative humidity
The simulation results in Appendix A showed that all points in (June) were equal to (58.82 %). And in (July) were equal to (58.86 %). they are no differences in the values for all points in the open space.

5. Conclusions
According to the results of the environmental simulation in a comparison tested point into the urban open space Al-Ghurery Square that: the Predicted mean vote near the arcade surrounding the semicircular building achieved better results as compare to street space. As for Mean radiant temperature, also the tested point near the arcade achieved reduction at about 4.3 C than street space. While the wind speed in the street space was more than the points inside the open space and near the arcade at about 3 m/s. which caused uncomfortable sensation for the pedestrian cause of the high temperatures that related with it. For the air temperatures and relative humidity for all tested point. It can conclude that characteristics formation for open space play an important role in thermal comfort for the pedestrians. The arcade formation contributed in achieves better results. That it can be depending by the architectures and planners to improve microclimate and thermal comfort to the pedestrians.
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### Appendix A

| PMV      | Tmrt  | Wind speed       | Air temperature |
|----------|-------|------------------|-----------------|
| ![Image1](image1.png) | ![Image2](image2.png) | ![Image3](image3.png) | ![Image4](image4.png) |
| Date   | Relative Humidity | Date   |
|--------|-------------------|--------|
| 19-7-2019 | ![Relative Humidity Chart 1](image1) | 19-6-2019 | ![Relative Humidity Chart 2](image2) |
