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Influence of morphological factors on the microclimate in urban public spaces
A study for hot and arid climate

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ABSTRACT/RESUME

Abstract:*The urban microclimate is influenced by several morphological parameters in urban public space. The height of buildings, the width of the streets surrounding this space and the orientation of its major axis control the absorption and reflection of solar radiation.*

These morphological parameters and others acting on the ambient temperature and determine the thermal quality of these spaces. The objective of this study is to characterize the thermal quality in outdoor urban spaces, more specifically in plaza, and to determine the influence of morphological factors on the modification of the urban microclimate.

We also try, to discover, through the study of four plazas, which one of theme it presents the good or the bad quality in terms of thermal environment, while trying to conclude the conditions generating this thermal quality; similarly, attempts are being made to find solutions that improve microclimatic features in plaza.

I. Introduction

In urban spaces, the microclimatic conditions in the public spaces are relatively complicated; it related to the form of public space, the nature and the type of surrounding spaces of an urban center. Microclimatic factors in the urban environment affected by shadows created by surrounding buildings that influence temperature, humidity and sun light [1], [2].

Urban public space is a vital space for the daily activities of residents and can provide residents with a comfortable living environment and improve their quality of life [3]. These Public spaces represent pleasant and comfortable places for the recreation and meeting of the inhabitants, especially in good microclimatic conditions. It has become clear that the relationship of people who use public places is closely related to the climatic conditions imposed on them, as it may increase or decrease their frequency to these places. Most climatic factors that affect the use of urban areas are solar radiation and temperature, which related to wind speed and relative humidity. Usually people prefer to sit in shaded places when the outdoor temperatures are high [4].

Many forms and spaces found in public spaces in cities, which have various characteristics that affect the local climate in these urban spaces, such as the type of vegetation cover, water levels and the height of buildings [5]. Many urban factors affect the urban microclimate, including the form of buildings and thermal characteristics of surfaces, which are important in determining the urban microclimate. We also find that the ratio between the height of buildings and the distance between them affects the amount of both incoming and outgoing radiation and affects wind speeds [6]. To reduce the high temperatures in the summer, some inexpensive measures can be used, such as planting urban trees, as well as using high-albedo urban surfaces [7]. The temperature in the air decreases also through the phenomenon of evaporation. Fountains and basins are one of the most important elements that help in

cooling the air by evaporation. The presence of any body of water in the external field reduces the temperatures of the surrounding surfaces with its high heat storage capacity [8].

In hot and arid climate, the great problem is uncomfortable climatic conditions in outdoor spaces that must necessarily find improvements to adapt the urban microclimate of the city. Environmental uncertainties pose a new challenge to planners, which should use different approaches for cities adaptation. The actual need for policies oriented towards climate change mitigation is a key role for reducing urban vulnerability and enhancing cities adaptation [9].

Biskra is a Saharan town, which have hot and arid climate, it characterized by impermeable public plazas that exposed to radiation all day long and suffer from the absence of vegetation and water spaces. This state makes these spaces uncomfortable climatically. The absence of vegetation in hot and arid climates has serious implications on the urban microclimate humidification [10]. In the city of Biskra, especially during the summer period, plazas are empty of inhabitants because they suffer from hostile climatic conditions. This study aims to evaluate and characterize the climatic conditions of four plazas in the city of Biskra in order to analyze and deduce the reasons for the bad thermal quality and to try to propose reasonable solutions. In addition, for the following secondary objectives:

• Demonstrate the variability of the thermal conditions in urban environments.

• Determining the role of urban morphology in changing the thermal conditions in the external urban space.

• Evaluate thermal conditions in the urban external spaces and identify the opportunities for users to adapt to changing the thermal conditions in environment.

II. Materials and methods

II.1. case stady and investigation

This study treat the subject of thermal conditions at the urban scale in Saharan environments, so we chose the summer period which presents the hot season of the year, where the microclimatic conditions are unfavorable. Like all Saharan cities, the city of Biskra (situated at south east of Algeria, see fig.1) characterized by a hot and dry climate; the microclimatic characteristics in outdoor public spaces manifested by:

• A very hot and dry summer where the difference in daytime temperature is important.

• A very cold winter at night compared to the day.

• The average maximum temperature reaches 45 ° C; it varies between 20 to 30 ° C in winter.

• Seasonal variation of 20 ° C.

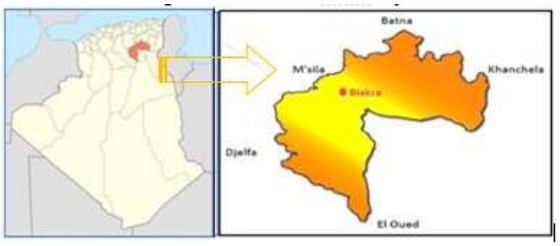

Figure 1. *Situation of Biskra city.*

Biskra is classified in the arid climate zone. The high amplitudes of heat present for a large part of the year vary from 26.5 ° C to 44 ° C (See Figure 2.).

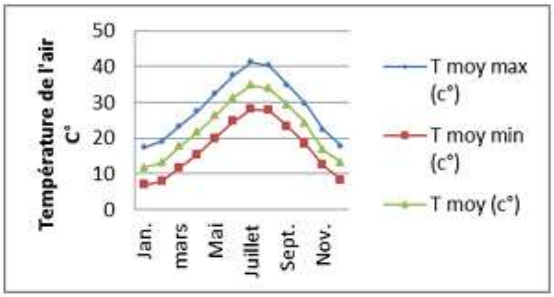

Figure 2. *Monthly averages of air temperature during the decade (2005 -2015).Source: Author*

This study solicits samples of public spaces of various shapes, but which are subject, under the influence of the same climatic conditions. The plazas chosen for this experiment are the following: El Houria plaza, Zouaka plaza: (Gattari El Okbi), Iben badis plaza and Dhalaa plaza (see Figure 3.).

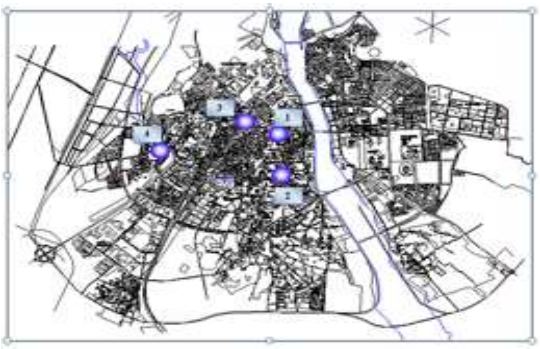

Figure 3. *Situation of the different plazas chosen (1: Elhoria plaza, 2: Zwaka plaza, 3: Dhalaa plaza, 4: Iben badis plaza, source: author according to the Biskra PDAU.*

"The term urban microclimate signifies local variations in wind, humidity; solar radiation and temperature, influenced by urban morphology parameters (build infrastructures, vegetation, surface materials)" [11]. Through this study, we aim to evaluate the microclimatic conditions in four plazas located in the city of Biskra through a comparative analysis according to the morphological characteristics of each plaza. Features of the different plazas are summarized in table 1.

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Table 1. *Presentation of the plazas that are studied.*

01. El-Houria plaza		
	EL-Houria plaza is located in downtown Biskra. It consists of a large esplanade, which contains a statue, and advertising panels on the upper part, it divided in two sides by a cascading stream on the lower part.	
02. Zwaka plaza		
	The Zouaka plaza is located at Hakim Saadane avenue; it was intended for the recreation of the inhabitants and it is used for the regrouping of the students of the high school Mohamed khireddine. This plaza is characterized by the lack of water and green space and the trees	
03. Dhalaa plaza		
	The Dhalaa plaza is located in the center of Biskra; with the 'Jebel Dhalaa, it means Montagne dhalaa'; which it bears this name. It devised on 3 parts, only one part of this plaza designated by this study, which has a triangular shape implanted above a cascade of water flowing with the slope of the mountain.	
04. Iben Badis plaza		
	The plaza of Iben Badis is located in the western area of the city of Biskra. , it is a recreation area for the inhabitants. This plaza has a regular shape; it covered with concrete pavement tiles and green spaces. High size trees are located in its peripheral zone. In the center of the plaza, there is a few of vegetation, small trees and a fountain (that does not work).	

II.2. measuring instrument

Companions are conducted in five single-day moments. Measurements are taken using a handheld instrument: TESTO 480 multifunctional anemometer (see Figure 4.). It is designed to acquire the four quantities to have either: Air Temperature (C °), Relative Humidity (%), Air Speed (m / s) and Radiant Temperature (C) °), with the use of a black ball probe, Ø 150 mm.

Figure 4. *TESTO 480 measuring instrument used in this experiment*

The measured climatic parameters include: air temperature (Tair), relative humidity (RH), wind speed and radiant temperature (MRT). *"MRT, defined as the uniform temperature of an imaginary enclosure in which the radiant heat transfer from the human body and the radiant heat transfer in the actual non-uniform enclosure are equal" [12].*
Measurements were taken at several points in each site with one point remaining constant approximately at 1.20 m height. Measurements are made under stable climatic conditions (clear sky, weak wind, strong sunshine).

III. Results and discussion

The microclimate in urban space is characterized by several spatial parameters, which can improve or change the quality of the urban microclimate. Few of these parameters we find, the albdo of the pavement materials, the nature of the vegetation cover, the orientation and the height / width ratio (H/W). The microclimate of urban space can be evaluated by air temperature (Ta), mean radiant temperature (MRT), relative humidity (RH) and wind speed (V). [13].
The results of this study show that the two plazas Elhoria and dhalaa have the lowest values of the air temperature. While the two plazas Iben Badis and zouaka represent the highest values of air temperature throughout the day than the other plazas (figure 5.).
The maximum of air temperature values are recorded in the afternoon after maximum heat accumulation with a difference of 2.4 ° C and 1.2 ° C recorded in the Zouaka plaza and the El Horia plaza in relation to the picked up by the weather station.

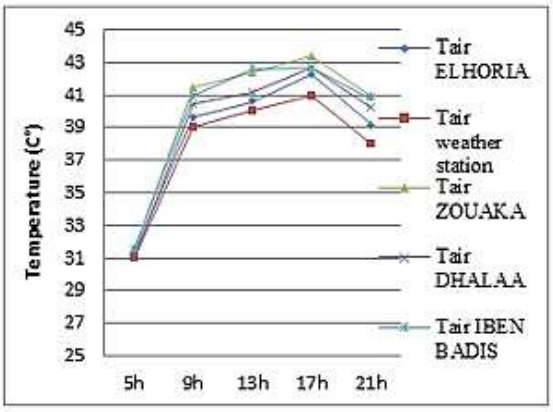


Figure 5. *Daily variation of Tair in the different plazas during a summer day.*

The increase in temperature at this moment may return to the increase of the mean radiant temperature because a significant difference was recorded between the values of the mean radiant temperature and the values recorded by the weather station in all the plazas (figure 6.). Especially in the Zouaka plaza or the mean radiant temperature reaches 45.3 ° C with a difference of 4.3 ° C with respect to the weather station.

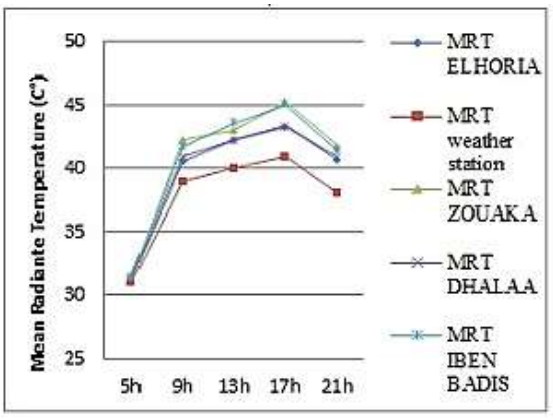
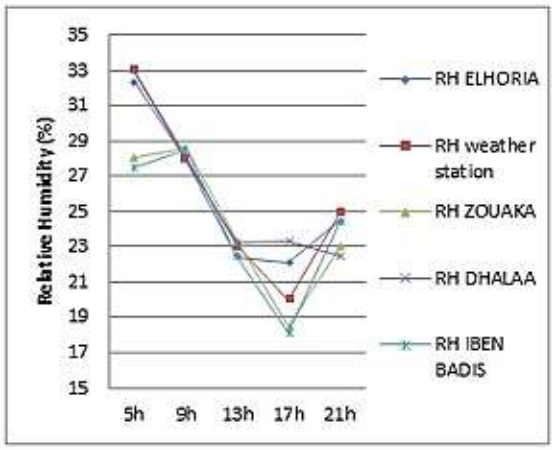


Figure 6. *Daily variation of MRT in different plazas during a summer day.*

It is found that there is a correlation between the relative humidity values measured in the El Horia plaza and the Dhalaa plaza; and another correlation between the values measured in the Zouaka plaza and the Iben Badis plaza.
During daytime, relative humidity registered in the selected plazas ranges from 18% to 33%. Within the same, relative humidity and wind speed, show a similar perception. Before sunset, we note that the values of the relative humidity will be higher in two plaza compared to the values recorded by the weather station (it is noted that the fountain is working at this time). There is a significant increase compared to the weather station in values of relative humidity in the plaza Dhalaa that arrives at (23.3%)

and other increase in the plaza El Houria that arrives at 22.1% (figure 7.)
The regulation of relative humidity is extremely important during summer and can be achieved through vegetation and the use of water surfaces [14].



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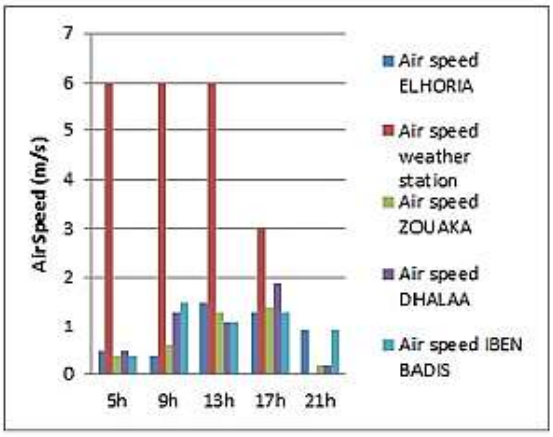

Figure 6. *Daily variation of MRT in different plazas during a summer day.*

IV. Conclusion

Thermal environment in the plaza depended on its geometry, vegetation and water features. In addition, these effects varied according to the macroclimatic conditions and the time of the day [16]. The results of measurements of climatic parameters in the plazas studied show that, the decrease of the air temperature, the acceleration of the wind speed and the elevation of the humidity of the air, comes down to the several factors. It relating to urban morphology (the opening to the sky, the orientation of the plaza in relation to the direction of the wind, the orientation in relation to the major axis, the nature and the color of the soil and the surrounding surfaces).
The presence of vegetal masses and water surfaces explains the elevation of the humidity of the air and consequently it is refreshing by evapotranspiration during the day. Shading trees provides a decrease in air temperatures. This case is found in the two plazas El Houria and Dhalaa where the presence of water plays an important role in the cooling of the air. This is what was observed in the last plazas when the values of the temperatures are lower compared to the other plazas under the effect of the presence of the water (fountain and basin of water). In the summer, evaporative cooling of the surface destabilizes the upper layer so that overturning brings warmer water to the surface and helps to maintain the almost constant temperature [17]. In the outdoor spaces, the shading resulting from the presence of trees and plants have an important role to reduce the high temperatures, and the evaporation of plants contributes to modifying the air by converting solar radiation into latent heat [18].
Shading helps to cool the air in the urban climate by blocking the sun's rays, which causes a reduction in temperatures in the shaded areas, where shading can reduce the surface temperature to 25°C [19].

V. References

1. Latini, G.; Cocci, Grifoni R.; Tascini, S. Thermal Comfort and Microclimates in Open Spaces. *Buildings XI* (2010) 1-10.
2. Zhang, X.; Zhang, Y., Zang, Q.; Yu, M.; Tong, Z. Comparative cognition of microclimate of different types of open spaces. In *24th International Conference on Geoinformatics* (2016) 1-7. Doi: 10.1109/GEOINFORMATICS.2016.7578970.
3. Xu, T.; Tong, Z.; Xu, S. Integration of Microclimate into the Multi-Agent System Simulation in Urban Public Space. *Smart Cities* 2 (2019) 421-432. Doi: 10.3390/smartcities2030026.
4. Nikolopoulou, M.; and Lykoudis, S. Use of outdoor spaces and microclimate in a Mediterranean urban area. *Building and Environment* 42 (2007): 3691-3707. DOI:10.1016/J.BUILDENV.2006.09.008.
5. Bourbia, F.; Boucheriba, F. Impact of street design on urban microclimate for semi-arid climate

(Constantine). *Renewable Energy* 35 (2010) 343–347. DOI: 10.1016/j.renene.2009.07.017
6. Johansson, E.; Influence of urban geometry on outdoor thermal comfort in a hot dry climate: A study in Fez; Morocco. *Building and Environment* 41 (2006) 1326–1338. https://doi.org/10.1016/j.buildenv.2005.05.022
7. Akbari, H.; Pomerantz, M.; Taha, H.; Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. *Solar Energy* 70 (2001) 295-310. https://doi.org/10.1016/S0038-092X(00)00089-X
8. Bouyer, J. Modélisation et simulation des microclimats urbains Étude de l'impact de l'aménagement urbain sur les consommations énergétiques des bâtiments. *Thèse de doctorat; école doctorale*: science pour l'ingénieur; géosciences; architecture. École Nationale Supérieure d'Architecture de Nantes. Université de Nantes (2009) 325 pages.
9. Tumini, I.; Rubio-Bellido C. Measuring Climate Change Impact on Urban Microclimate: A Case Study of Concepción. *Procedia Engineering* 161 (2016) 2290 – 2296.
10. Sebti, M.; Alkama, Dj.; Bouchair, A. Assessment of the effect of modern transformation on the traditional settlement 'Ksar' of Ouargla in southern Algeria. *Frontiers of Architectural Research* 2 (2013) 322–337.
11. Chatzinikolaou, E.; Chalkias C.; Dimopoulou E. Urban microclimate improvement using envi-met climate model. *The International Archives of the Photogrammetry; Remote Sensing and Spatial Information Sciences* XLII-4 (2018) 69-76.
12. Shahab, K.; Sabarinah, Sh.A.; Megawati O.; Norhati, I. Urban outdoor thermal comfort prediction for public square in moderate and dry climate. *In IEEE Symposium on Business; Engineering and Industrial Applications (ISBEIA); Langkawi; Malaysia.* (2011) 308-313. DOI: 10.1109/ISBEIA.2011.6088827
13. Othman, A.A.; Abdin, A.R.; Amin, A.A.; Mahmoud, A.H. A bioclimatic design approach for the urban: open space design at business parks. *Journal of engineering and applied science* 67 (2020) 1883-1901. Faculty of engineering, Cairo university
14. Teli, D.; Axarli, K. Implementation of bioclimatic principles in the design of urban open spaces: microclimatic improvement for the cooling period of an open space adjacent to the sea. *In 25th Conference on Passive and Low Energy Architecture (2008).*
15. Nikolopoulou, M. Designing Open Spaces in the Urban Environment: a Bioclimatic Approach. *Centre for Renewable Energy Sources* (2004).
16. Shahab, K.; Sh. Ahmada, S.; Saberi, A. Microclimatic Conditions of an Urban Square: Role of built environment and geometry. *Procedia - Social and Behavioral Sciences* 170 (2015) 718– 727.
17. Oke, TR. Boundary layer climates. London: *Methuen* (1987).
18. Dimoudi, A.; Nikolopoulou, M. Vegetation in the Urban Environment: Microclimatic Analysis and Benefits. *Energy and Buildings* 35 (2003) 69-76. Doi: 10.1016/S0378-7788(02)00081-6.
19. Gaitani, N.; Spanou, A.; Saliari, M.; Synnefa, A.; Vassilakopoulou, K.; Papadopoulou, K.; Pavlou, K.; Santamouris, M.; Papaioannou, M.; Lagoudaki, A. Improving the microclimate in urban areas: a case study in the centre of Athens. *Building Services Engineering Research and Technology* 32 (2011) 53–71. DOI: 10.1177/0143624410394518

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