International Journal of Innovative Studies in Sociology and Humanities
ISSN 2456-4931 | Open Access | Volume 7, Issue 6, 2022
DOI: https://doi.org/10.20431/2456-4931.0706003

Investigation of the Influence of the Buildings Density on the Air Temperature in Urban Neighborhood in Hot, Dry Cities

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Abstarct

Since the first sight of human habitation in a desert environment, the strategy of urbanization, it was compact urban fabric where a high building density, streets and narrow alleys, it's in order to reach a maximum of protection of climatic factors, especially protection of high air temperatures, the research methodology of this paper is based on three main axes: which are 1- a survey of Climatic factors 2- the second axis, it was regression analysis 3- the third axis, which is the discussion of the results of the survey and regression analysis, we conclusion is the six times which analyze indicated a existence regression singnificant for one period, which is the daytime of the summer only, where sig =0,00, sig ≤ 0,05, also the field survey analysis indicated an difference in air temperature within neighborhoods (F1,F2,F3) at the daytime of the summer only, where the difference reached 4,2 co.

Key words: The Buildings Density, The Air Temperature, Neighborhoods, The Linear Regression, Biskra City.

INTRODUCTION

The public spaces play a large role to define the quality of life experienced by citizens. For this reason, it is essential that urban public spaces be comfortable and attractive(Qaoud & alkama 2017). The outdoor spaces in the neighborhoods are fundamental for the social life due to their capacity to serve as meeting spaces and interactions among the public (Boukhabla et all 2014), especially in cities of desert, the environmental quality conveys a sense of well-being and satisfaction to its population through characteristics that may be physical, social or symbolic (Theodore et all 2003) also the environmental quality is a complex issue involving subjective perceptions, attitudes and values which vary among groups and individuals(Krüger et all 2010) the environmental conditions influencing well-being in the built environment: thermal, visual and acoustic, as well as air quality (Monika, & Pawel,2010).

MATERIALS AND METHODS

Study Area

The city of Biskra is located in the southeast of the country's capital with a distance of 430 km Biskra city is a link between the north and the south of Algeria, its called through the ages the gate of desert.

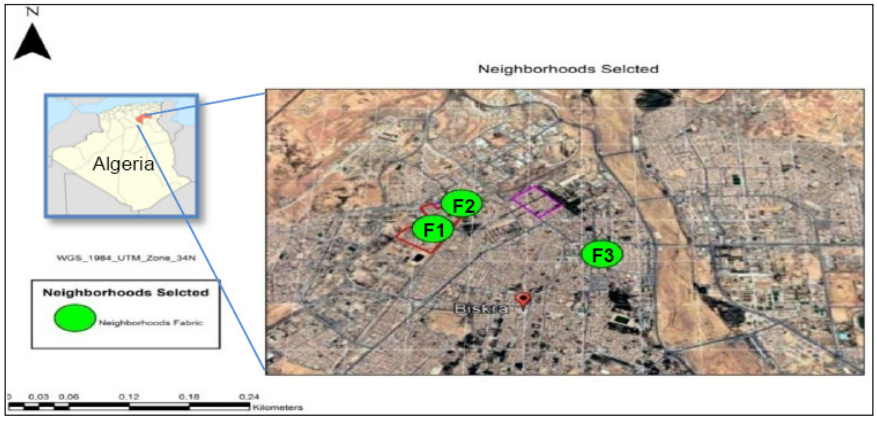

Figure 1. The neighborhoods selected in Biskra cite.

the city is located in the northern part of the state according the coordinates, east of the green-wich line, longitude 5°,43 east and northeast latitude 34,51° north (Qaoud & alkama 2019), the sample study included a three urban fabrics of neighborhoods in the city center area, with different types of buildings density, the neighborhoods called , 1- al istqulala(F1), 2- al-nassr(F2), and 3- al-zamala(F3), its representing all patterns building density in neighborhoods across the city according to the density indicators, the sample will be arranged in ascending order from the smallest to the largest density.

The Measuring Stations

There were 30 measuring stations as flowing figure, 10 stations for each neighborhood to measure climate factors, the measuring stations were distribution in serial order a central of each neighborhood, and in different directions in order to get the average values of climate factors be correctly and confirmed from each fabric of neighborhood the measurement was taken every two consecutive hours throughout 24 hours a day, so the measurement was taken a 25-26/07/2021the summer season, 15-16/05/2021the spring season, 27-28/02/2021 the winter season. As table No 1 where the average of Technical parameters of each neighbourhood.

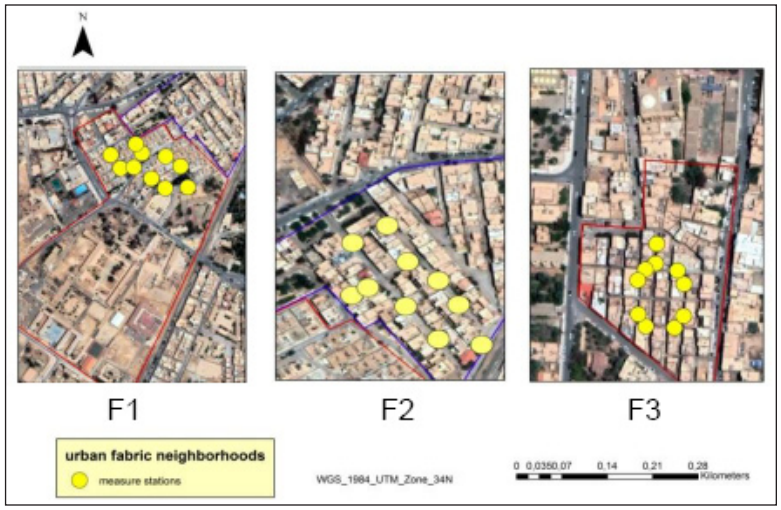

Figure 2. The measuring stations within urban fabric.

Table 1. The Technical Card of Neighbourhood data.

average	Al-istquala Neighbourhood N1	Al-Nasr -Neighbourhood N2	Al-Zamala Neighbourhood N3
BD	12/ha	35.51/ha	59.52/ha
floor	1	2	*2+TR*
H	3,6	8.33	*8.33*
W	9	8.16	*3,8*
H/W	0,40	1,02	*2,1*
Dir-tion	Nw/Se	Nw/Se	*N/S*
S,V,F	0,77	0,42	*0,22*
FICHE EYE			

Literature Review

There are some literature which related to the research work in the study area, we mention the works of b, mofidah, k, hamel, and m,al-hadi, their study focus on studying the effect of street engineering and urban fabric morphology on thermal comfort and the heat island in city of Biskra among those works, we mention the following 1- (k hamel, & mazouz 1997) where the study of the compact city an urban shape for sustainable city, in arid areas, 2- (Hamel khalissa, et all 2021) this study show the impact of the palm grove and the built density on the urban microclimate in Ossian

environ-ment, 3- (Boukhabl & alkama2012)where study of the impact of vegetation on thermal conditions outside, thermal modeling of urban microclimate, case study, the street of the republic Biskra, 4- (Boukhabla, et all,2014) the energy balance behavior in open street case study city of Biskra, Algeria, 5-(Al-hadi et all,2021) prediction of climate change effect on outdoor thermal comfort in arid region, through the previous literature review, we can shed light on the research gap of this paper, it was represented in the fact that none of the previous research works had previously addressed the relationship between variable of buildings density of urban fabric and air temperature, as most of the literature of studies in the region dealt with street architecture or the openness or closure of the street and its relationship to indicators of thermal comfort and the heat island.

Research Objectives

The objectives of the research is a good understanding of the reasons how the buildings density of neighborhoods affects in the air temperature within the outdoor urban space, defining the statistically relationship which links the urban fabric morphology and air temperature, determine the best type of building density of neighborhoods in hot cities which can affect and reduce of the air temperature.

Methods

The research methodology of this paper is based on three main axes: which are 1- a survey of climatic factors (air temperature, relative humidity, wind speed) during three seasons of the year, which are winter spring and summer and the sample analyzing according to building density indicators, 2- the second axis, it was regression analysis this in order to infer statistically the effect of the density of buildings of neighborhoods on the air temperature which is the H/W as an independent variable and the air temperature as an dependent variable, 3- as for the third axis, which is the discussion the results of the survey and regression analysis.

Examined Variables

In this research paper, we studied and analyzed several variables related to building density and climate factors, these variables were classified on the basis of independent and dependent variables.

The Independent Variable

They represent the independent variables which responsible of the effect that occurs on the phenomenon, here in this study, the independent variables was represent the building density of the fabric, for example the sky view factor variable(S,V,F). it's a coefficient of sky view factor, its a fractional number is limited from 0 to 1 (Khaled,2008), H/W variable it's the ratio of the height of the buildings to width of street, the building density variable (BD), which expresses by the number of building/ha(Roberts,2006), the building coverage ratio (BCR) which expresses by surface of building /ha(Omar et all,2020). In this context, the previous literature review conducted at similar goals and locations, it's relied on (H/W)(S.V.F) variables (Roberts,2019) so hence, in this paper, we use variable that represent the density urban form which is (H/W) specified as the independent variable.

The Dependent Variable

The dependent variables which is the variables affected of the phenomenon, in this study, it's was represent by the climate factors , for example. The air temperature variable is great interest to studies that charge the thermal comfort in the outdoor (R, Compagnon,2004), the most studies are interested of thermal performance in the outdoor spaces focus on the variable of the air temperature (You Peng,2021), it's the result of a interaction between the natural component and the built component, in this paper, the air temperature variable (AT) as the dependent variables.

The Survey

The field survey, More than 360 measurements of air temperature were taken during three seasons of the year, summer, spring and winter, through 30 measurement stations, each 10 measurement stations in each neighborhood.

The Regression Analysis

We applied the regression analysis with a simple linear regression to analyze the relationships between independent H/W variable with dependent AT variable (Air temperature) at three seasons of the year during the daytime and night-time of each season.

RESULTS

Aspects of Comparison

The Survey Data

In the winter seeson as figure No3 the difference in air temperature values did not exceed 0.6°C at daytime and 0.4C° at nighttime which indicates the weak effect of the building density of fabric on the air temperature. Where the average of values of air temperatures recorded - neighborhood (F1) 23.1C°, neighborhood (F2) 23.3C°, neighborhood (F3) 22.7C° at day-time, also the average of air temperatures recorded neighborhood (F1) 11C°, neighborhood (F2) 11.1C°, neighborhood (F3) 10.7C° at night-time .

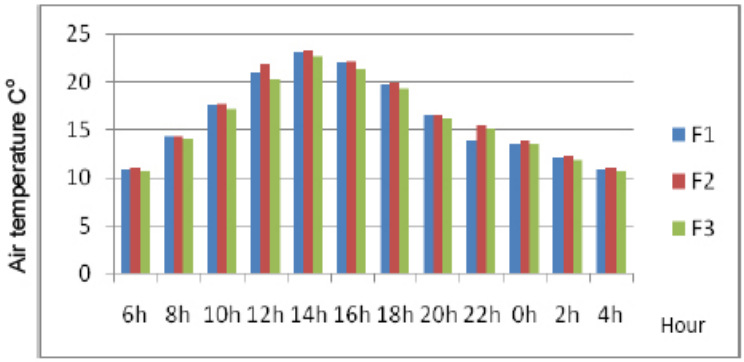

Figure 3. The histogram of survey data during the winter season.

In the spring Season figure No4 the average of values of air temperatures are recorded at day-time in neighborhood (F1) 33.8C°, neighborhood (F2) 33.6C°, neighborhood (F3) 34C°. also the air temperatures are recorded at night-time in neighborhood (F1) 22.4C°, neighborhood (F2) 22.3C°, neighborhood (F3) 22.5C°. Thus the air temperature difference reached 0.4°C at day-time and 0.2 C°, at night-time, the datas indicates the weak effect of the building density of fabric on the air temperature.

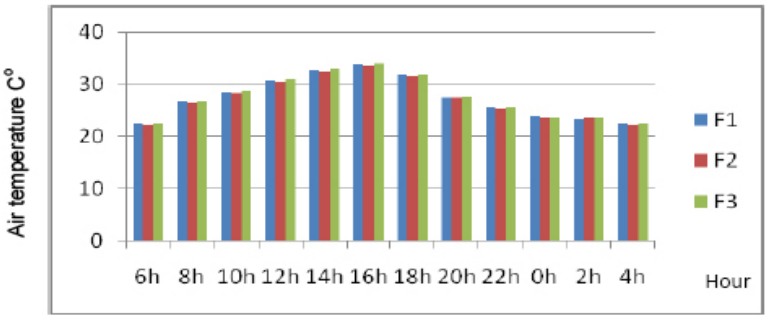

Figure 4. The histogram of survey data during the spring season.

In the summer season as figure No 5 the results clearly showed the difference in air temperature values reached 4.2°C at day-time, where the effect of the building density of fabric on the air temperature, the average of air temperatures values at day-time within neighborhood (F1) 46.1°C, neighborhood (F2) 44.43°C, neighborhood (F3) 41.87°C, also the air temperatures values at night-time within neighborhood (F1) 32.1°C, neighborhood (F2) 31.9°C, neighborhood (F3) 32°C. where the difference reached 0.2 C° of the air temperature reached at night-time which indicates the weak effect of the building density.

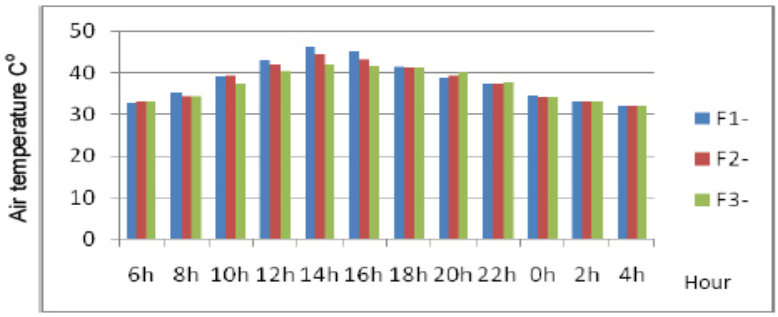

Figure 5. The histogram of survey data during the summer season.

The Regression Data

According the results of the regression analysis, the results indicated a existence statistically significant for one period, which is the day-time period of the summer only, where sig =0.00, sig ≤0.05. Through table No 2 too the (B) is a negatively sign at day-time for all seesons, and positively sign at night-time for all seesons.

Also the highlest values of (B) was in summer seeson where B=-0.213, (R2) =0.68, (sig)=0.00, the relationship between the two variables is an inverse relationship , and the independent H/W variable has a strongly effects on the dependent variable AT during the daytime of the summer, on anther hand the values in the rest of the periods is low or almost non-existent.

Table 2. The statistically significant data.

Season	*Time*	*R2*	*constant*	*B*	*SIG*
Summer	Da-time	0,68	41,43	- 0,213	0,00
	NI-time	0,004	33,98	0,004	0,737
spring	Da-time	0,059	30	- 0,023	0,198
	NI-time	0,003	23,38	0,006	0,758
winter	Da-time	0,11	19,25	-0,021	0,001
	NI-time	0,000	12,48	0,001	0,944

Aggregation of Results

By data collection of the survey and regression, as fig No 6 , 7 and table No3 there is a correlation of the statistical function and variance in air temperature during the daytime of the summer, where B=0.213-, R2=0.68, sig=0.00, variance of AT=4.2 oc. Also, by comparing the results between the different seasons of the year, it's the variance which was in the day-time in summer seeson.

So the actual effect of the building density on the air temperature was during that period, which is what the survey and regression results indicated.

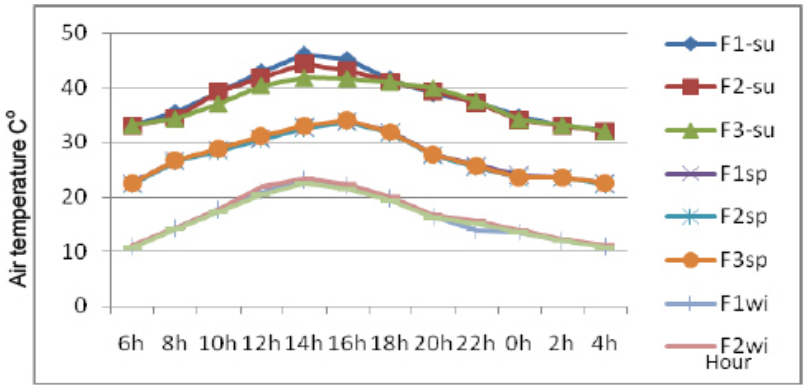

Figure 6. The Curve of survey data during the summer season.

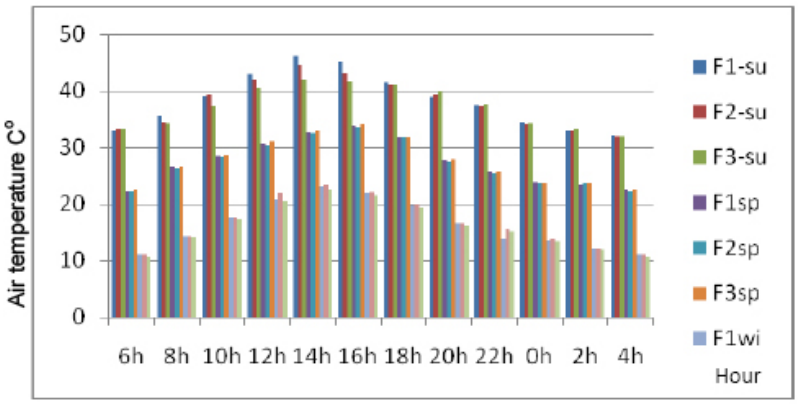

Figure 7. The histogram of survey data during all seasons.

Table 3. The results of the regression with the air temperature difference,

	summer season		spring season		winter season	
	D-time	N-time	D-time	N-time	D-time	N-time
sig ≤0,05	0,000	0,737	0,198	0,758	0,063	0,944
AT-dif	4,2	0,2	0,4	0,2	0,6	0,4

DISCUSSION

The discussion is based on study of the phenomenon from the physical side, where the study depends on evaluating the impact of density of urban fabric on the physical environment factors Without addressing the aspect of thermal comfort or comfort indicators or introducing the human element into the variables which studied. Therefore, the frame built of fabric which is the effective effect on the air temperature to protection from direct solar radiation and providing more hours of shade, through the results obtained in the previous section, shown in Figure No 7, 8 . We can say that dense fabric has the lowest of air temperature compared to other fabric in the sample. Therefore, the density of the neighborhood had a strong role in protecting from solar radiation load in the built environment and the air during the peak time of the year, where the difference of air temperature between dense and less dense neighbourhoods =4.2 co at summer.

Planning Strategies of Urban Fabric of Neighbourhoods

The most of dessert cities is a lack of the modern technology which can reduce the air temperature, so the best strategy is the alternating shade via the height of the buildings or the trees with a great height, it's a only way to effect the air temperature and reduce of heat, its for due of the importance the outdoor spaces within the neighborhoods which include many activities related to different ages of population, the designers must ensure that the outdoor space is always shaded during the daytime especially in the summer.

CONCLUSION

The shade which is the technique of built environment to influence on air temperature by a series of simultaneous effects thus, the buildings density is provide the shade which a lower of air temperature values , the surveying of literature, has been proven that shading lower the air temperature and increases the rate of thermal comfort, therefore, the increase in the buildings density of urban fabric can be increased in the number of hours of shade and lower the air temperature within outdoor spaces of the neighborhood.

There is also a statistical function between the building density variable and the air temperature variable, therefore there is a strong relationship between the two variables, and the reason of variation in air temperature is the building density of neighbourhoods, this relationship could predicted mathematical, in final, we can say that the building density of urban fabric of neighbourhoods can improve the air temperature of the outdoor space in hot, dry cities .

Further Study

Maybe there is a future study regarding of the behavior of the buildings density towards the physical factors of the nature environment such as the sound variable, natural lighting and wind, a future study of relationship of buildings density with air temperature according to type of climate different, also the relationship between building density of neighborhoods and social phenomena such as social interaction within the outdoor space of neighborhoods.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

-Competing of interests

The author(s) declare that they have no competing interests.

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DOI: https://doi.org/10.20431/2456-4931.0706003.