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Effect of A High-Density Street-Level on Air Temperature in Outdoor Space of Neighborhoods of Hot, Dry Cities

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Abstract
The outdoor spaces of residential neighborhoods are an important part of residents' lives the outdoor spaces in the neighborhood are fundamental for the social life due to their capacity to serve as meeting spaces and interactions among the public, here comes this search, which is based on study of the role of highdensity –street level- on air temperature in outdoor space of neighborhoods. The methodology was based on three parts, initially, determine the sample which is three downtown residential neighbourhoods according to scientific criteria. secondly, conducting a field survey of climatic factors (air temperature - relative humidity - wind speed) thirdly, make a model to simulate the built environment by using the envi-met 4.4.6 program, according to the data of the survey, the results indicated that significant variations of value of DSR, MRT, AT variables among residential neighborhoods which points the effect of high-density street-level on air temperature in outdoor space .
Keywords: Direct Sw Radiation (DSR); Mean Radiant Temp (MRT); Air Temperature (AT); Outdoor Spaces; envi-met Model.

1. Introduction
The outdoor spaces of residential neighborhoods are an important part of residents' lives the outdoor spaces in the neighborhood are fundamental for the social life due to their capacity to serve as meeting spaces and interactions among the public (Theodore, 2003). Therefore, the urban designer is always working to make a safe of the natural environmental conditions, especially in environments with high thermal loads. and well-being of urban environment for the residents within the outdoor spaces. The environmental quality is a complex issue involving. Subjective perceptions attitudes and values which vary among groups and individuals (E,L, Krüger, 2010) where the environmental conditions influencing on well-being in the built environment: thermal, visual and acoustic, as well as air quality(Chan IYS, 2018) but the air temperature in the built environment is the dominant factor while others may also contribute to the overall comfort(M, Boukhabla, 2012). In this regard, the most of the ancient cities in the desert of Middle East to North Africa are applying the technique of compact fabric in order to reduce the high temperature of the air .In this research paper, we will try to explain this phenomenon scientifically and provide a scientific understanding of it, in order to develop knowledge that can be useful for designers and urban managers for future desert cities.

2. Materials and Methods
2.1 Methods
The research methodology was based on several sequential phases. The first is choose the sample according to specific criteria in order to be sample is represents all types of building density of residential neighborhoods in the city. Hence, conducting a field survey of climatic factors (air temperature - relative humidity rate - wind speed). According to specific criteria for that, exeilty 7/25,26 where the peak of air temperature of year. and using a scientific measurement devices approved (Qaoud, R, Djamal, A, 2017; Mandal, & Byrd, 2017), (B,moufida, D,alkama, 2014). After that, we are making a model to simulate the built environment by using the Envi-met 4.4.6 program, according to the data of the survey, with a margin of error does not exceed the scientific criteria. It’s in order to study the direct solar radiation variable, the average radiant temperature variable, and the air temperature variable within several building density. Finally, the discussing of the results to reaching a good understanding of the phenomenon and predicting its behavior in the future.

2.2 Study Area

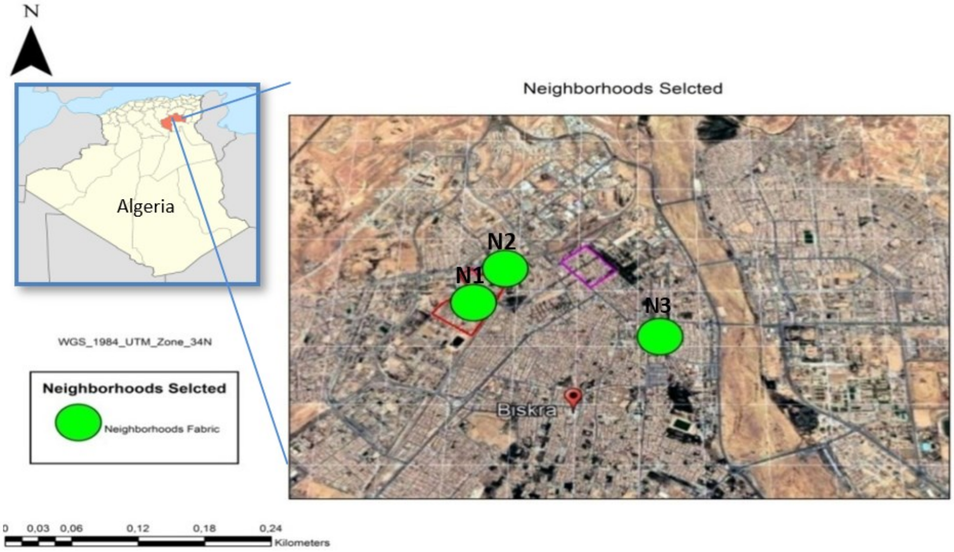

Figure 1. The neighborhoods selected of the sample.

The city of Biskra is located in the southeast of the country's capital with a distance of 430 km through the ages Biskra city is a link between the north and the south of Algeria, its called the gate of desert, the city is located in the northern part of the state and occupies an area estimated at 12,770 hectares, according the coordinates the city is located to the east of the green-which line, longitude 5°,43 est and northeast latitude 34,51° north (Qaoud, R, Djamal, A, 2019), where The previous figure shows the location of the city of Biskra in the state of Algeria As well as the location of the residential neighborhoods N1,N2,N3 as a sample in the city of Biskra.

2.3 The Measuring Stations

As shown in fig following There are 9 measuring stations of the sample, 03 stations for each neighborhood in order 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, the measurement was taken a 25-26/07/2021 at the summer season, Instruments Used for The Meteorological Measurements according to the human scale.

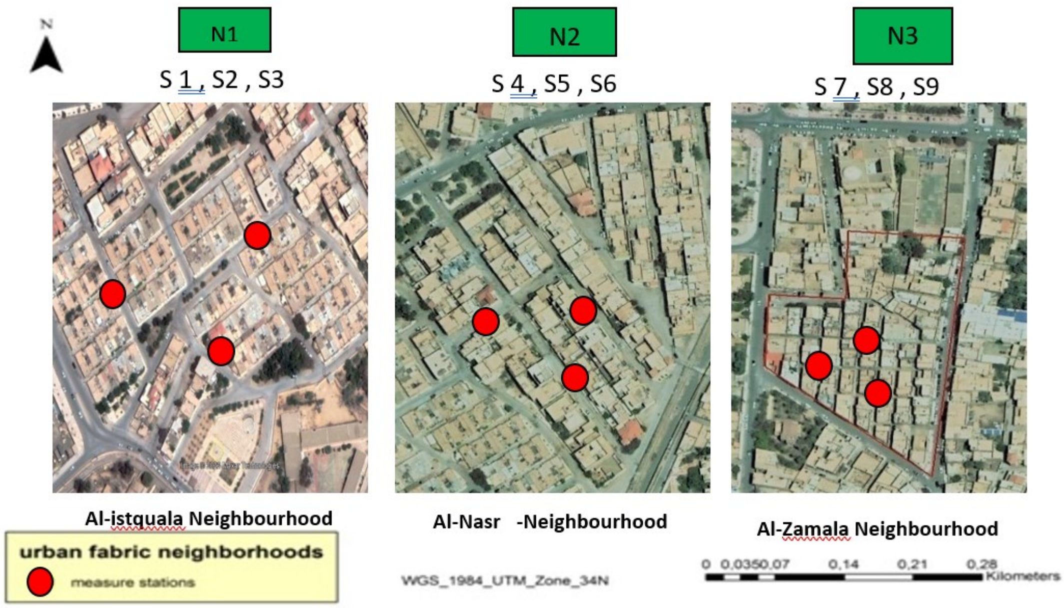

Figure 2. The measuring stations within urban neighborhoods

2.4 The Measuring Stations Technical Card

Table 1. Summary of Technical Card of N1, N2, N3

	Al-istquala Neighbourhood N1			Al-Nasr -Neighbourhood N2			Al-Zamala Neighbourhood N3		
N⁰ .S	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
BD		12/ha			35.51/ha			59.52/ha	
N°,etage	1	1	1	2+TR	2	2	2+TR	*2+TR*	2+TR
H	3,6	3,6	3,6	9	8	8	8	*8*	9
W	9,8	7,3	9,8	9,5	7,5	7,5	3,8	*3,8*	3,8
H/W	0,36	0,49	0,36	0,95	1,06	1,06	2,1	*2,1*	2,36
D,STR	Nw/Se	Nw/Sw	Ne/Se	Ne/Sw	Nw/Se	Nw/Se	N/S	*N/S*	w/e
S,V,F	0,81	0,71	0,81	0,46	0,42	0,42	0,23	*0,23*	0,21
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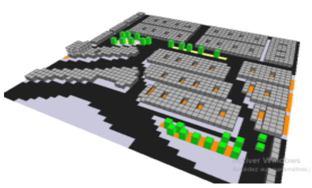
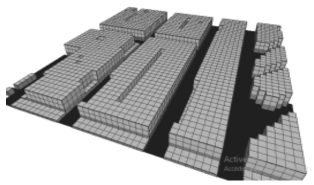
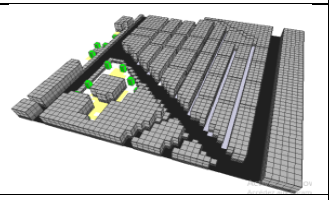
2.5 Simulation Settings and Validation

In this study, where we simulated using a program Envi-met v,4,4,6 in two and three-dimensional simulation this technique is often used to simulate urban built environments (Omar M, Galal, and All, 2020) this is during the period of the actual impact of the building density of neighborhoods on air temperatures (during the summer), envi-met has been also acknowledged for its ability to calculate direct, diffuse , reflected solar radiation and mean radiation temperature (Matallah, M.E, and all, 2021) all of this which significantly affect air temperature , this simulation draws upon on measurements which was taken on the 25th and July 26, 2021 for average of air temperature and relative humidity were taken at different points within Biskra's three neighborhood, hence there was no worries regarding any sort of interferences or the safety of the measuring tools, which accredited by the university of Biskra.

2.6 The Simulation Settings of the ENVI-Met Mode V,4,4,6

Table 2. Summary of the simulation settings of the ENVI-met

Parameters	Al-istqulal neighborhood (N1)	Al-Nassr neighborhood(N2)	Al-Zamala neighborhood (N3)
3D model			
Date of Simulation	25/07/2021	25/07/2021	26/07/2021
Start time	05:00 AM	05:00 AM	05:00 AM
Total simulation time(h)	24	24	24
Number of main area grid boundary	x-50, y-50, z-25		
Size of grid cell in meter	dx=3,00 dy=3,00 dz=3,00 base height		
Wall material	Albedo 0,2		
Roof material	Albedo 0,6		
Soil profile	Albedo values as follow: pavement 0,5, asphalt 0,12, sand 0,31		

Wind speed at 10 m height	1.2 m/s following weather station records of Biskra's airport
Wind direction	135° from north
Roughness length	0,07
Simple forcing air temperature (oC)	Min 33,00 at 06:00, Max 45,00 at 14:00
Simple forcing relative humidity (%)	Min 9 at 13:00, Max 21,5 at 06:00
Nesting grids	None were used since no buildings are placed near the edge of the model,

Table 3. Summary of the validation of the simulated models

Indices	Al-istqulal neighborhood (N1)		Al-Nasr neighborhood(N2)		Al-Zamala neighborhood (N3)	
RMSE	0,78	3,26%	0,61	2%	0,67	2,43%
MBE	-0,15	-0,78%	0,08	0,43%	0,19	1,02%

According to the literature review the ASHRAE guideline 14, the simulation model is considered validated if the hourly (MBE) values are within +-10%, and hourly (RMSE) values are below +- 30%, (Matallah, M.E, and all, 2020) (46), some literature mentions that used only the air temperature for the comparison between the simulated and measured data therefore, we have adopted the modeling results, this in accordance with the auditing standard.

3. Results

3.1 Aspects of Comparison

The comparisons of the simulation results are performed on three scales between the chosen samples; N1, N2, N3
1- Comparison of geometric parameters and density variables (H/W) (S.V.F) for each residential neighborhood
2- Comparison of variables of climatic parameters (DSR)(MRT)(AT)
3- Comparing the relationship between density variables and climatic variables (H/W) (S.V.F)/ (DSR)(MRT)(AT).
Through the screening of average SVF and H/W values. can be found in table 1. the neighborhood N1 had a (SVF=0.77 , H/W=0.40), N2 had a (SVF=0.43 , H/W=1.02), N3 had a (SVF=0.22 , H/W=2.18), the results of the screening which has SVF higher for N1, and less for N3. and which has H/W higher for N3 and less for N1. Hence when the screening of average DRS, MRT, AT at day hours. the neighborhood N1 had an average (DRS=726.56 W/M2) N2 had a (DRS=537 W/M2), N3 had a (DRS=195.3W/M2) can be found in table 4, the screening of MRT at day hours can be found in table 5. the neighborhood N1 had a average (MRT= 67.59c) N2 had a (MRT=50.96c), N3 had a (MRT=43.41c), when the screening of average AT at day hours the neighborhood N1 had an average (AT= 41.04c) N2 had a (AT=39.75c), N3 had a (AT=38.28c) can be found in table 6. the results of the screening which has (DRS) higher for N1=726.56 w/m2, and less for N3=195.3 W/M2, the screening which has (MRT) higher for N1=67.59c, and less for N3=43.41c and the screening which has AT higher for N1=41.04c, and less for N3=38.28c, so neighborhood N1 has a higher of DRS.MRT.AT. and the neighbrohood N3 is the less of DRS.MRT.AT.

3.2 Impact of High-Density Fabric on Climatic Parameters

This selection for the urban density variables scale with climatic parameters the comparisons of the simulation results is performed on three scales DRT MRT AT between the three chosen samples; N1, N2, N3.
The SVF, and H/W screening was performed of average values of the climatic variables demonstrated a noticeable sensitivity to variations in urban form It reached its highest values in the neighborhood N1 on anther hands the climatic variables is demonstrated lessest values in neighborhood N3 where the neighborhood N1 which has a H/W=0.40 S.V.F=0.77 notes a DSR= 726.56 w/m MRT=67.59c AT=41.04c. and neighborhood N3 which has a H/W=2.18, S.V.F=0.22 notes a DSR= 195.3 W/M w/m MRT=43.41c AT=38.28c as show in Fig. 3(a,b,c) also notes to a big differences in value of climatic parameters variables among the N1,N2,N3 neighborhoods of the sample, where the variance of the values DSR reach 531.26 W/M2 at day hours , so the hours of insolation in neighborhood N1 reach 11 hours during day hours, it was in the neighborhood N3 a 3 hours during day hours, by review the table. 4 in contrast the hours of insolation, shows too the hours of shading where value= 0 of insolation, which the variance of shading hours. where neighborhood N1 has 3 hours of shading during day hours in all directions, but N3 which has 12 hours of shading during day hours in direction N/S and 10 hours a direction E/W average shading hour (shH) 11 hours per daytime also the variance of the values of MRT=24.18c and AT=2.76 at day hours between N1 and N3, therefore, N3 is neighborhood denser than N1. the neighborhood N3 which has the lowest values of climatic factors it's also has a high percentage of H/W and also a low value of S.V.F, as shown in tables 1, 4,5,6. it seems there is a consistent impact of density on the different climatic parameters.

Table 4. Summary of the Direct S.W. Radiaation (DSR) values of the simulated models

Direct SW Radiation	Al-istqulal neighborhood (N1)			Al-Nassr neighborhood(N2			Al-Zamala neighborhood (N3)		
measuring points / HOUR	p01	p2	p3	p4	p5	p6	p7	p8	p9
6,00	0	0	0	0	0	0	0	0	0
7,00	565	0	565	0	0	0	0	0	0
8,00	805	805	805	0	0	0	0	0	0
9,00	925	925	925	925	925	925	0	0	925
10,00	991	975	991	994	991	994	0	0	994
11,00	1025	1025	1025	1025	1025	1025	0	0	0
12,00	1040	1040	1040	1044	1040	1040	1040	1040	0
13,00	1040	1040	1040	1040	1040	1040	1040	1040	0
14,00	1038	1038	1040	1040	1040	1040	0	0	0
15,00	1015	1015	1015	1017	1015	1015	0	0	0
16,00	970	970	970	970	970	970	0	0	970
17,00	890	890	890	0	0	0	0	0	890
18,00	725	720	725	0	0	0	0	0	0
19,00	325	0	325	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0

Table 5- Summary of the Mean Radiant Temp (MRT) values of the simulated models

Mean Radiant Temp	Al-istqulal neighborhood (N1)			Al-Nassr neighborhood(N2			Al-Zamala neighborhood (N3)		
measuring points / HOUR	p01	p2	p3	p4	p5	p6	p7	p8	p9
6,00	22,5	22,5	22,5	23	23,5	23,5	18,8	18,8	18,8
7,00	32,5	32,5	32,5	28	28	28	22,4	22,4	22,4
8,00	72,5	65,5	72,5	33	33	33	26,8	26,8	26,8
9,00	77,5	77,5	77,5	42,5	42,5	42,5	33,9	33,9	65,3
10,00	77,5	77,5	77,5	68,5	69	69	42,5	42,5	69,1
11,00	77,5	77,5	77,5	69	69	69	51,25	51,25	56,15
12,00	77,5	77,5	77,5	69	69	69	60	60	43,2
13,00	77,5	77,5	77,5	69,2	69,2	69,2	66,3	66,3	52,4
14,00	82,5	82,5	82,5	72,5	75,1	75,1	51,5	51,5	51,5
15,00	87,5	87,5	87,5	77,5	77,5	77,5	52	52	52
16,00	87,5	87,5	87,5	54,5	54,5	54,5	52,5	52,5	79,1
17,00	84,6	81,2	84,6	52,5	52,5	52,5	47,3	47,3	76,2
18,00	75,6	74,3	75,6	42,5	42,5	42,5	42,3	42,3	42,3
19,00	52,5	42,5	52,5	34,25	34,25	34,25	32,2	32,2	32,2
20,00	37,5	32,5	37,5	26	26	26	22,1	22,1	22,1

Table 6- Summary of air temperature values of the simulated models

Air Temp	Al-istqulal neighborhood (N1)			Al-Nassr neighborhood(N2			Al-Zamala neighborhood (N3)		
measuring points / HOUR	p01	p2	p3	p4	p5	p6	p7	p8	p9
6,00	33,5	33,5	33,5	33,5	32,5	32,5	33,5	33,5	33,5
7,00	34,5	34,5	34,5	33,5	33,5	33,5	34,5	34,5	33,5
8,00	36,5	35,5	36,5	34,5	34,5	34,5	34,5	34,5	34,5
9,00	38,5	38,5	38,5	37	36,5	36,5	36,5	36,5	35,5
10,00	39,5	39,5	39,5	38,5	37,5	37,5	37,5	37,5	37,5
11,00	41,5	41,5	41,5	40,5	39,5	40	38	38	38
12,00	41,5	41,5	41,5	41	42	41,5	38,5	38,5	38,5
13,00	43,5	43,5	43,5	42,5	43,5	43,5	40,5	40,5	40,5
14,00	44,5	44,5	44,5	43,5	44,5	44,5	40,5	40,5	41
15,00	45,5	45,5	45,5	43,5	44,5	44,5	41,5	41,5	41,5
16,00	45,5	45,5	45,5	43,5	44,5	44,5	41,5	41,5	41,5
17,00	44,5	44,5	45,5	43,5	43,5	43,5	41,5	41,5	41,5
18,00	43,5	43,5	44	42,5	42,5	42,5	40,5	40,5	40,5
19,00	42,5	42,5	42,5	40,4	40,5	40	38,5	38	38,5
20,00	40,5	40,5	40,5	37,5	37,5	37,5	37,5	37,5	37,5

3.3 The Variations of Climatic Parameters in The Sample N1-N2-N3

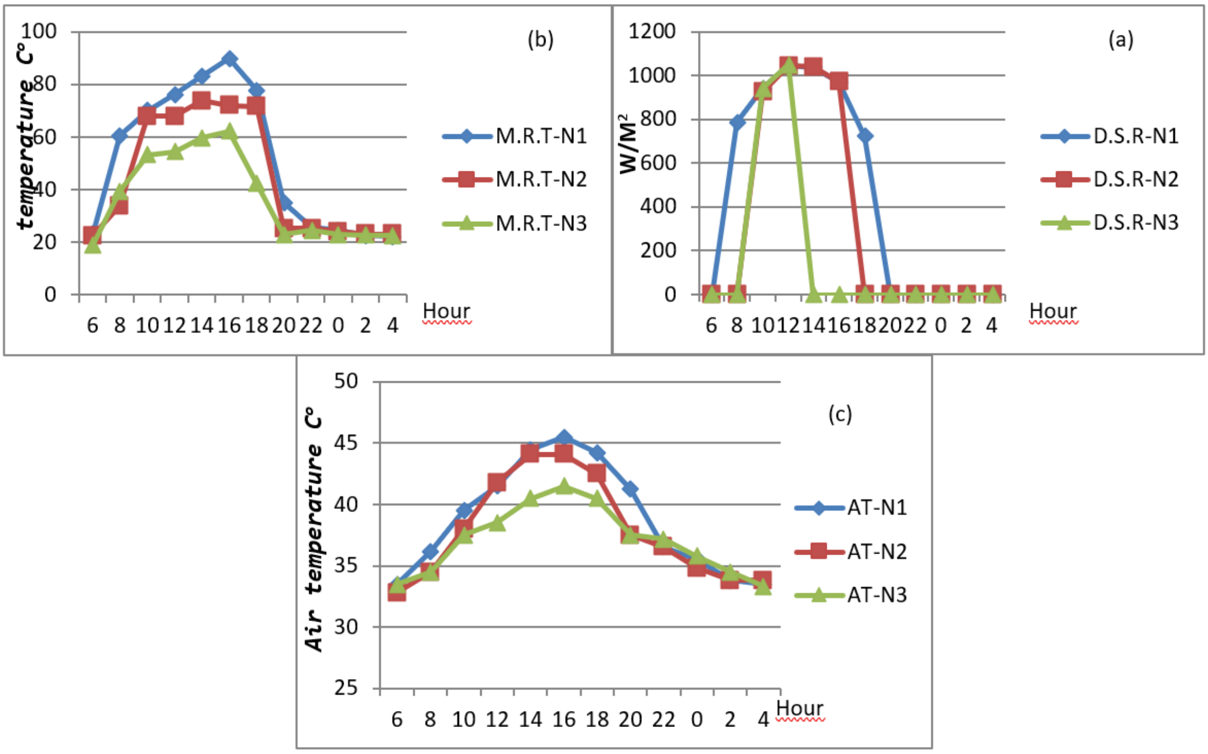


Figure 3. (a) The variations of DSR Variable (b) The variations of MRT Variable (c) The variations of AT Variable.

3.4 The Simultaneous Effects of High-Density Fabric

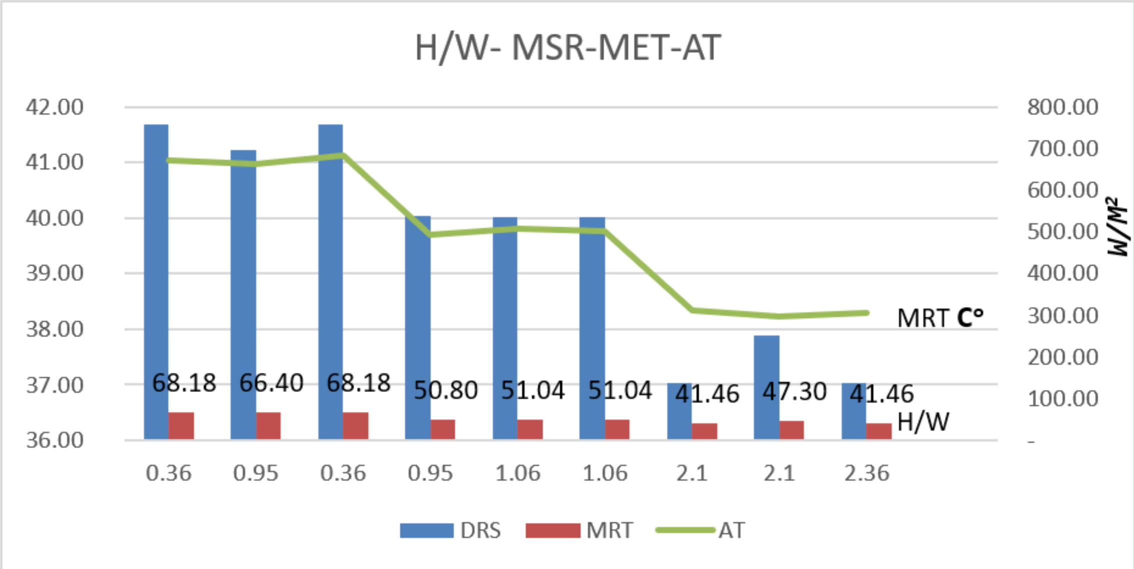


Figure 4. The simultaneous effects of H/Won MSR-MET-AT Variables

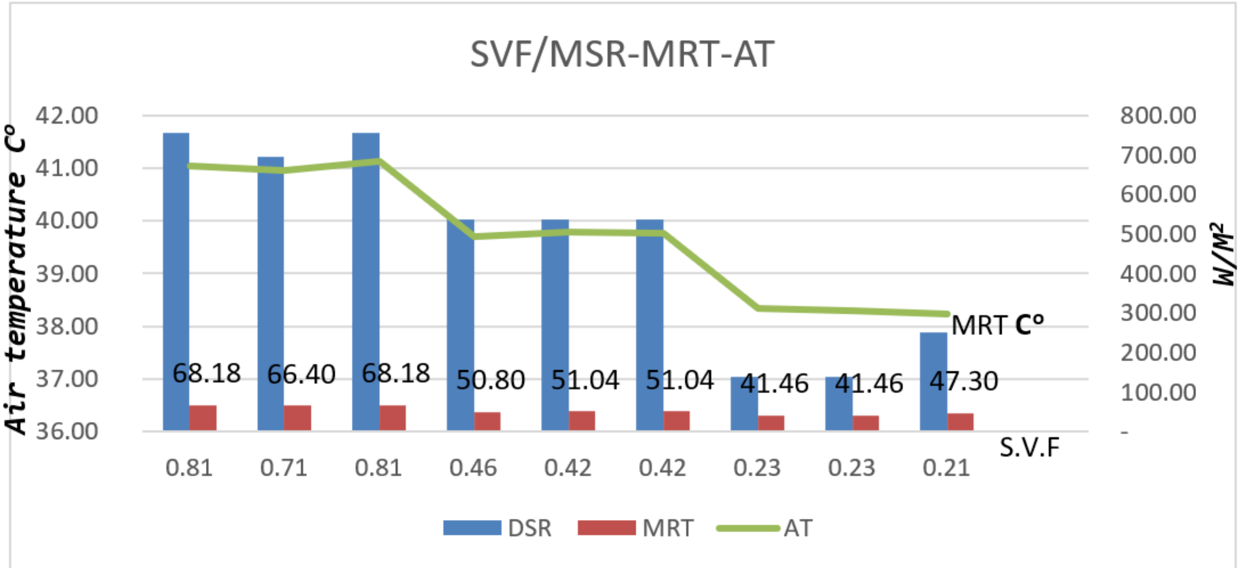


Figure 5. The simultaneous effects of H/Won MSR-MET-AT Variables

4. Discussion

The effect of the buildings density on climatic parameters occurs through simultaneous effects in terms of urban form and climatic parameters. It's directly affects on the geometry of the outdoor space by determining the values of the urban form density variables H/W, S.V.F. as a result of the it's coming the effect on the amount of solar radiation that enters to outdoor space of neighborhood , as well as the hours of insolation and shading, and thus the amount of thermal energy of the built environment stores, and finally effect on the air temperature within the outdoor space.

The air temperature is the result of the thermal interaction between the air and the built environmental temperature. Where the neighborhood N3 which higher density had values less of average S.V.F=0.22 and the values of the climate parameters were average DSR=176.42w/m, average MRT=43.41average AT=38.28. Where the neighborhood N3 which higher density had values higher of average H/W. Which is the results clearly indicated in table No 1 and Tables No 4,5,6, The neighborhood N1 which the least dense had values higher of average S.V.F=0.77 and higher than the climatic factors DSR=736.73w/m, average MRT=67.59 average AT=41.04, In this regard therefore, after examining all the results, the urban form density variables (H/W,S.V.F) has a directly affect on the climatic parameters variables (DSR,MRT,AT,suH) The literary reviews have proven that there is a correlation between building density (H/W) /(S.V.F)on (AT)(suH)(PET), also there is an relationship and effect suH on AT so We confirm the validity of these relations and we add to it The relationship between (H/W) /(S.V.F) and (DSR,MRT). In finily, the densest urban fabric which has the higher value of H/W and, the least of S.V.F, DRS.MRT. and AT. Therefore, the neighborhood which more dense, that lower of the air temperature within the outdoor space.

5. Conclusion

The shade is the technique to enables the built environment to influence the air temperature by a series of interconnected influences or simultaneous effects, Through simulation results, we conclude that the neighborhood more dense is provide the shade which provide a lower of the amount of direct radiation, also provide a lower of average radiant temperature Subsequently, the average air temperature is low, so with a surveying the results of the literature, it has been proven that shading lower the air temperature and increases the rate of thermal comfort, therefore, the increase in the density of urban fabric will lead to an increase in the number of hours of shade in the outdoor spaces of the neighborhood and lower the air temperature and increases the rate of thermal comfort. Therefore, the High-Density fabric improve by simultaneous effects on climatic parameters in outdoor space of neighborhoods of hot, dry cities.

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Conflict of Interests

The authors declare no conflict of interest.

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