THE MICLOCLIMATE OF THE COURTYARDS IN BUILDING BLOCKS: SIMULATION OF THE MICROCLIMATE OF A BUILDING BLOCK AND RESEARCH OF THE IMPROVEMENT POTENTIAL THROUGH THE RECONFORMATION OF EACH OPEN SPACE.

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ABSTRACT

The speed of reconstruction in the big cities of our country, the need of the inhabitants for affordable housing and the lack of environmental conscience in the past years, led to the expulsion of natural elements from the cities. Vacant land has been reduced to a bare minimum and nowadays it is vital that nature returns in these areas. Making the best of the remaining urban vacant space is one of the last possibilities for urban recovery. Sustainable architecture design of the vacant areas inside a building block can contribute to the change of the overall image of the city by improving the quality of life. The object of the present work is to investigate the possibility of improving the microclimate and thermal comfort conditions through the redesign of the free spaces inside a building block. For this purpose, building block 179 in the center of the city of Serres was chosen. With the help of the ENVI-met simulation program, the current situation and the improvement proposal are evaluated. The data analyzed led to the conclusion that bioclimatic interventions related to the use of cold materials and the increase of natural elements (low green, trees, water) improved the thermal comfort conditions for the users of the area.

KEYWORDS

building block; vacant areas; microclima; thermal confort; ENVI-met

1. INTRODUCTION

The rapid development of Greek cities led to densely built up and densely populated urban centres. The microclimate that is formed in an urban area is influenced by human activity and the form of the built environment, in addition to the special weather conditions that prevail in each area. The degradation of the natural environment and the lack of quality urban green spaces in the urban fabric of the city have negative consequences not only on the formation of the microclimate, but also on the quality of life and consequently on the mental and physical health of its inhabitants. (Nilsson, et al. 2011).

Based on the microclima's ideal size an environmental regeneration can be proposed because it influences directly the place where people live, work and are affected by the city's negative consequences on them. (Tumini, 2015)

The urban climate is a combination of microclimates that is produced by the roads and in the open spaces between buildings. It depends by the physical and functional

characteristics and the morphology of the immediate environment. (Oke, 1987)

The building block is the basic organizational cell of the urban fabric. (Gerolimbou, et al. 1986) The way it is structured affects the overall image of the city. The redesign of the valuable free spaces of each building block according to bioclimatic criteria can improve the microclimate and the thermal comfort conditions of the inhabitants of the whole city.

Studies conducted to improve the microclimate of outdoor conditions in recent years are increasingly using simulation models. The scientific community has turned to the study of these models in an effort to assess the impact in time and to improve urban redesign proposals.

2. METHODOLOGY

Initially, the research refers to the effect of outdoor design, materials, plantings and other parameters on the microclimate and comfort conditions that develop within the urban fabric. For this purpose, the evolution of the legislative framework regarding the configuration of the courtyards has been taken into account.

The research, then, focused on the scale of a building block, the block (179) in the city of Serres where the current situation was studied and the renovation of its free spaces was proposed.

The block 179 was chosen because it brings together a wide variety of different features that allow the conclusions to be generalized from the level of a building block to the city level.

The paper is completed with the evaluation of the improvement achieved through simulation with specialized software and concludes with general instructions for the optimal design of building block.

3. STUDY AREA

3.1. The city of Serres

The city of Serres is the capital of the municipality of Serres, belongs to the Administrative Region of Central Macedonia in Greece (Figure 1).

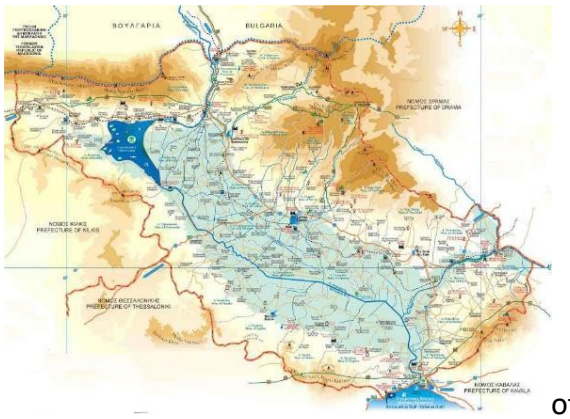

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Figure 1 (Research Area) (www.serres.gr)

Characteristics of the city

- It is located at an altitude of 50m above sea level and for the most part it is almost flat (www.serres.gr).
- It belongs to the 3rd climatic zone, which means that it consists of buildings with high energy consumption needs for their cooling and heating (OJHR, 2017).
- Its population amounts to 58,287 inhabitants (HSAG,2011).
- It is classified in the 2nd level category of residential centres, which have services that cover the area of Serres, while there are operations in the city that have radiation outside the area of Serres.
- According to the new General Urban Planning (GUP) (OJHR,2013) the city is divided into 17 urban units, which are grouped into seven districts.

3.2 The building block 179

The Building block 179 is located in the city centre, between Merarchias St, Thessalonikis St, Redestou St and Alexandridi St. In fact, these are two building blocks in 179 and 179a that are separated by a narrow street, Delaporta St. (Figure 2).

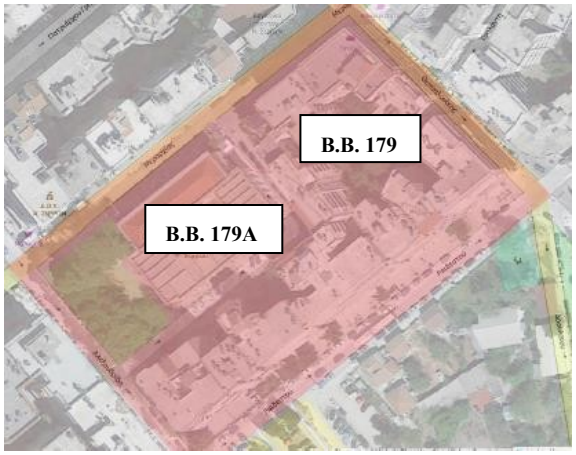

Figure 2. Study area

The building block 179 has significant courtyards of different forms (interior courtyard, lawn, unstructured plot, small square, roads that can become areas for pedestrians). It has a section with high and densely built buildings and a section with low construction and, finally, it is at a key point for the creation of a green network in the city.

3.3 Regeneration proposal

The proposed interventions (Figure 3, 4) aim at improving the microclimate of the area and the thermal comfort conditions, especially during the summer months, therefore great emphasis is placed on increasing the green areas, on the extensive planting of new trees and the use of cold materials and water elements.

Figure 3. Master plan

Figure 4. 3ds proposal

3.4 Evaluation of the proposal using software

The evaluation of the proposal was done with the use of the ENVI-met simulation software (www.envi-met.com).

Air and surface temperatures, wind speed and PMV thermal comfort index were studied during a typical day of the hottest month of the year, before and after the application of the configuration proposal.

The data entered in the program are presented in the following table (Table 1):

Table 1 (Study area data).

Geographical location of the city of Serres	23°33′ (length) 41°05′ (width)
Simulation day	20 July 2018
Simulation duration	24 hours
Wind direction	West
Dimensions of geometric model	50 * 50 cells of 30 cells height
Grid analysis on the horizontal and vertical axis	5m
Model dimensions	250m x250m

A typical summer day was chosen for the simulation. The highest temperature observed on this day was recorded at 17:00 when it reached 32.38^{O}C and the lowest at 4:00 where 21.23^{O}C was recorded. Respectively, the highest relative humidity was presented at 4:00 (67.55%) while at 17:00 (28.55%).

The direction of the prevailing winds, according to HNMS, was set to be west. Soil moisture was set at 60% and 70% at the upper and lower soil levels respectively.

The building shells, located in the study area as mentioned above, are made of conventional materials (concrete, brick) and are mostly covered by roof. The reflectivity of the building materials was set at 0.5. Their heights range from 4m up to 18m.

Both during the simulation of the current situation and that of the intervention proposal the building shells remained stable. Elements, such as the green walls that existed in the proposal to renovate the central courtyard, were not calculated due to program constraints. The elements that differ in the two simulations cover an area of 7475m² and relate to flooring materials, planting surfaces, trees and water elements (only when they occupied large areas). The percentages of participation of the individual elements in the total area as well as the areas they occupy are shown in table 2 below.

Table 2. Percentage of participation of the individual elements in the whole surface and areas

	Now		After proposal	
	Area (m2)	percentage %	area (m2)	percentage %
total area	7475		7475	
asphalt	1900	25,42%	0	0,00%
grey paving materials	3675	49,16%	0	0,00%
cool paving materials	0	0,00%	3425	45,82%
cement	750	10,03%	0	0,00%
Impervious to water paving	0	0,00%	1100	14,72%
wood	0	0,00%	225	3,01%
green area	525	7,02%	2825	37,79%
water area	0	0,00%	125	1,67%
ground	625	8,36%	0	0,00%

As mentioned above, the simulations covered a period of twenty-four hours and the results regarded the air and surface temperatures, wind speed and the PMV thermal comfort index prevailing in the area before and after the regeneration proposal.

In order to be able to quantify the results, 15 points were selected which are scattered in the study area. Three points were selected in each section (Thessalonikis St, Redestou St, Central courtyard, Delaporta St and Court of Law Square) and an average result was emerged from them for eight specific hours of the day 03:00, 06:00, 09.00, 12.00, 15:00, 18.00, 21:00 and 00:00 (Figure 5).

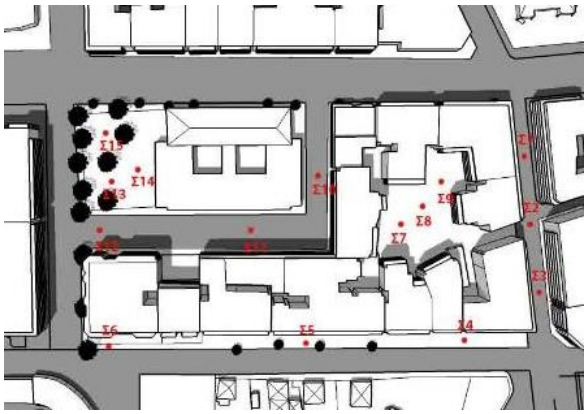

Figure 5: Points of observing the results

The proposal for the renovation of OT 179 included:

- The unification of its two sections with the conversion of the intermediate small road into a pedestrian street
- The increase of the green area by 30%, the replacement of the asphalt surface on Delapotra St with water permeable materials and on Thessaloniki St with cold materials.
- The replacement of existing dark paving slabs with green surfaces and cold materials.
- The addition of water surfaces at 3% of the total area
- The planting of a large number of new trees.

3.5 Results

The aforementioned interventions brought about a significant reduction of the surface temperature which is more intense during the noon (Figure 6).

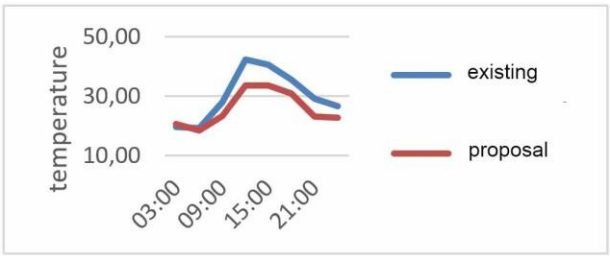

Figure 6. Surface temperature

Contrary to the temperature of the surfaces in the simulation of the intervention proposal, the air is colder in the morning, while during the

day it reaches the same levels as in the current situation and in the afternoon it exceeds them. At night, however, in the proposal the air temperature is almost 2^{O}C lower (Figure 7).

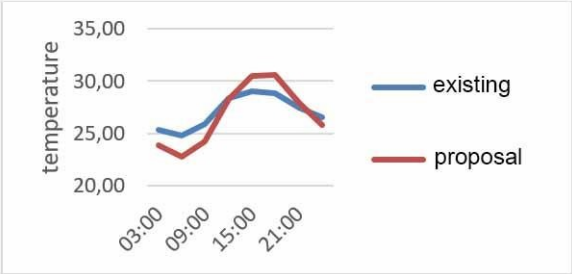

Figure 7. Air temperature

Wind speed seems to be favoured by the increase in green areas as it seems to show higher values throughout the day (Figure 8).

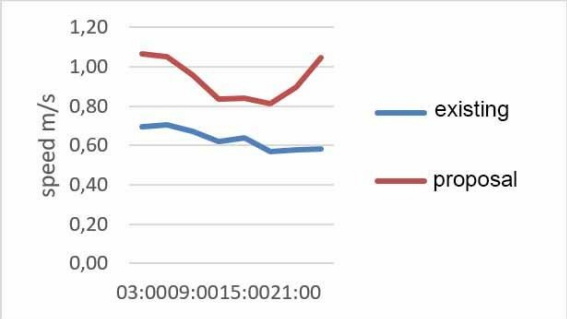

Figure 8. Wind speed

Finally, the PMV thermal index shows that thermal comfort for users has improved significantly although it remains high during the afternoon (Figure 9).

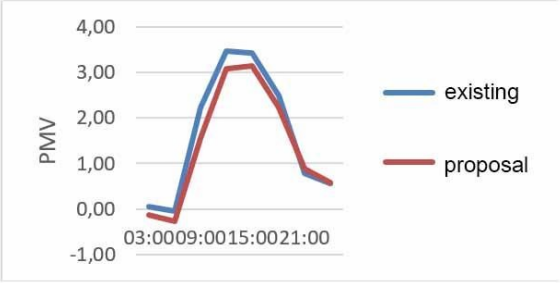

Figure 9. Thermal index PMV

4. CONCLUSIONS

The research showed that:

- The improvement of the microclimate and the conditions of thermal comfort affect the use of an urban space but also the quality of life of the inhabitants.
- The extensive use of natural elements (green, water) as well as the replacement of impermeable coating materials with water-permeable ones with a high reflectivity index (cold materials) contribute to the improvement of the microclimate and thermal comfort conditions of the building block and consequently can help to improve the conditions of the whole city.
- The unification of the uncovered areas of the building blocks can contribute to the improvement of the conditions of the area, but this also requires the cooperation of the citizens.

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