The microclimate in housing estates in the Northeast of Brazil

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ABSTRACT: This work studies the microclimate in housing estates of the Northeast of Brazil, in Teresina, located at 05°05' south latitude, with 750,000 inhabitants approximately. The regional climate is classified as tropical continental, with wet summers and dry winters. The annual average temperature is 28°C. The research objective is to verify if the climate conditions in housing estates can be considered heat islands, as a result of their constructive characteristics. The two housings estates analysed have 25 and 10 buildings with 04 floors and 16 apartments in each building. Analysed were the density, topography and ground use of the surroundings, the wind and solar direction of the buildings, the ground covering, the distance between buildings and the height / width relations. Measurements of the air temperature, relative humidity, wind direction and velocity were done in five external points in each housing estate, for three days, at 09:00am, 03:00pm and 09:00pm, in the hot dry season. The results were compared to the data of the meteorological center of the city. The research showed that the housing estates created microclimates in the urban area that can be considered heat islands, due to their characteristics.

Key words: urban climate; housing estates

1. INTRODUCTION

The regional climate is modified by various factors in the cities such as high density of the built areas, in substitution of the foliaged, not paved areas, the heat production due to anthropogenic activities such as industries, vehicles and equipment, the reduction of vegetation and the pollution. These alterations originate the urban climate, that is different from regional climate in its elements.

In the urban areas, all the climatic elements are altered regarding the rural adjacent area: the temperature of the air is higher, the relative humidity is lower, the winds are modified in direction and speed and the rainfalls are more frequent.

The climatic elements are modified by the local factors and they determine the microclimate. According to Romero [1] and Szokolay [2], we stand out:

a) Topography: declivity, direction, exhibition, elevations or nearby valleys of the place;

b) Surface of the ground: natural or artificial, albedo, permeability, temperature of the ground, paved areas or vegetation;

c) three-dimensional Objects: trees, shrubs, walls or buildings once these can influence the winds, produce shadows and subdivide the area in smaller spaces with different microclimates;

Lynch [3] emphasizes the importance of the microclimatic conditions for the designers, since such conditions interfere in the thermal exchanges and of water vapor between the environment and the built spaces. The exchanges of heat for radiation, convection and conduction, correspond to three physical characteristics, the albedo, the conductivity and the turbulence, resulting from the materials and forms chosen in the project.

Regarding the open areas, the sensation of comfort of the user is determined by the climatic elements temperature, relative humidity and speed of the air and also by the solar straight, indirect and diffuse radiation incident in the environment, as well as of the thermal radiation of the surfaces of the area built. In this way, the constructive characteristics and the materials employed in the roads and public spaces will contribute significantly to the sensation of comfort.

The performance of the urban areas, therefore, depends on the characteristics of the climate, the morphology and the materials used in the urban enclosure that must be employed in accordance with the climate of the region, in order to obtain spaces appropriate to the human activities.

Romero [4] presents a model of bioclimatic analysis of the urban space based on the modifications of the natural environment produced by the process of urbanization. These alterations interfere in the local climate producing urban microclimates, modify the propagation of sound and light in the urban environments and cause alterations in the form materialization process. The thermal balance between men and the environment is broken, bringing serious consequences to the quality of urban life and to the environmental sustainability.

In this context and aiming to a correct approximation of the transforming actions of the natural way, the purpose of this work is to analyze the thermal performance of the open areas of two

housing estates built in Teresina, the Santa Marta Condominium (1990) and the Hebrom Condominium (1989) and to check if the climatic conditions of the estates can be considered islands of heat in the city, in function of their constructive characteristics.

Teresina is located at 05°05' south latitude and at 42°48' west longitude. The regional climate is classified according to Koppen as megathermal sub wet climate (Aw).

The climate in Teresina presents two quite different seasons, dry winters and summer rains, corresponding to the tropical continental climate, once the city is located far from the coastal belt. According to Silveira [5], during the first semester the climate is hot and wet, with the average of the maximum temperatures between 30 to 32°C and relative average humidity between 75 to 85 %. The rains are concentrated in this period, from December to May. (figures 1 and 2)

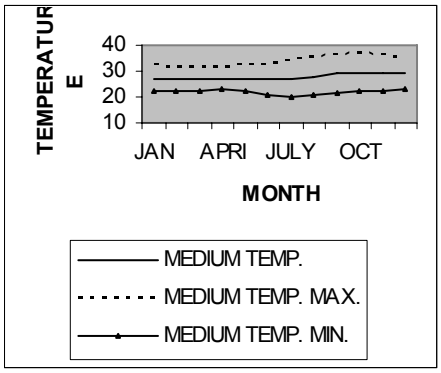

Figure 01: Teresina – Average temperatures

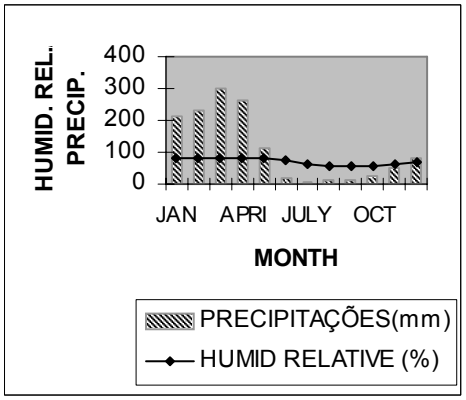

Figure 02: Teresina – Relative humidity and rainfalls

In the second semester, there are practically no rainfalls, the climate is hot and dry, with maximum average temperatures between 33 to 36°C and relative air humidity between 55 to 65 %. There is an elevated presence of calmness, around 40 % of the hours of the year and the winds are weak, with an average speed of 1,4 m/s and predominant south-east direction.

We work with the hypothesis that, the housing estates, in function of their dimensions and of the characteristics of the built areas and of the open spaces, induce the formation of microclimates that interfere in the thermal performance of the buildings. In this sense, the treatment given to the open spaces, in terms of ground covering, vegetation, solar direction and to the winds and morphology is determinative in the conditions of thermal comfort and use of these areas.

The open spaces, under the bioclimatic approach, must be projected like "mediators between the external climate and the environment in the interior of the public space demarcated" [1], creating spaces that contribute positively to the environmental comfort of the external and internal areas of the constructions. The author groups in four great categories the elements to be analysed in the study of the public spaces: the form, the sketch, the surface and the area and she presents the main characteristics of each one of the categories that must be considered in the analysis of the urban spaces.

2. USED METHOD

Many studies have been performed to verify the microclimatic conditions and urban spaces comfort, trying to determine the best situations, for each climate type, which allows the use of spaces such as squares, streets and sidewalks by the population. These works show that the urban microclimate is determined by the alterations made by men in the environment.

Duarte, D. and Maitelli, G. [6], Castelo Branco [7], Costa and Araújo [8], Silva and Corbela [9] carried out works that use experimental-theoretical method, relating the urban drawing and the characteristics of the materials of the open areas with the local climatic variables.

In this line of work, we analysed the thermal performance of the open areas of two housing sets in Teresina, connecting the characteristics of these areas with the result of measurements of temperature, relative air humidity and speed of the winds done in the place and with the data registered in a meteorological center of reference in the city.

Concerning the housing estates, we can emphasize the following parameters:

a) the area: topography, density and use of the ground;

b) the housing estate: tax of occupation of the ground, built density, penetration of the winds and solar direction;

c) the open areas: surface of the ground, foliaged areas, height and distance relation between the buildings;

The measurements of climatic variables were done in November, for three days, at 09:00am, 03:00pm and 09:00pm. The climate in this year period is dry and hot, with high temperatures during the day and low relative humidity. These values (the average of climatic variables measured in each hour) were compared to the data collected on the same days in the meteorological center of EMBRAPA. This center is situated in the suburbs, surrounded by foliaged areas and with low density. The statistical treatment of the collected data was done by using the SPSS program.

3. RESULT ANALYSIS

Initially, with the support of architectural projects the characteristics of both housing estates were studied in loco.

3.1 The Santa Marta Condominium

The Santa Marta Condominium was built by a private company in 1990. It has an area of 3.8 hectares with 400 apartments distributed in 25 blocks. Each block has 04 floors and 04 apartments, with 72,0 m² of built area each one. The area has low density, flat topography, residential ground use, with uni and multifamily dwellings and a great foliaged area situated in the west. In the east, there is another housing estate with the same configuration and occupation tax.

According to the situation plan (figure 03), the blocks have east-west orientation and a 19 meter minimum distance between them, allowing the predominant winds from southeast.

Figure 03: Santa Marta Condominium– Situation plan

The height versus width relation between the blocks is low, equals 0.68, assuring good ventilation conditions in the open areas. The ground occupation tax is little, only 21,11% and 30% of the ground is paved by impermeable materials.

3.2 The Hebrom Condominium

The Hebrom Condominium, built in 1989 by a private company, has 140 apartments, distributed in 10 blocks with 04 floors each one. Half of the ground floor is open, with pilotis, used as garages. The apartments have 91,40 m² of built area each one. The area is characterized by low density, with many trees and has residential use.

The situation plan (figure 04) shows that the blocks have east-west orientation. The buildings are very near, with height and distance relation of H/W=2,13 between them. The ground occupation tax is high, 45,29% and 31,26% of ground area is paved with impermeable materials that absorb great part of incident solar radiation.

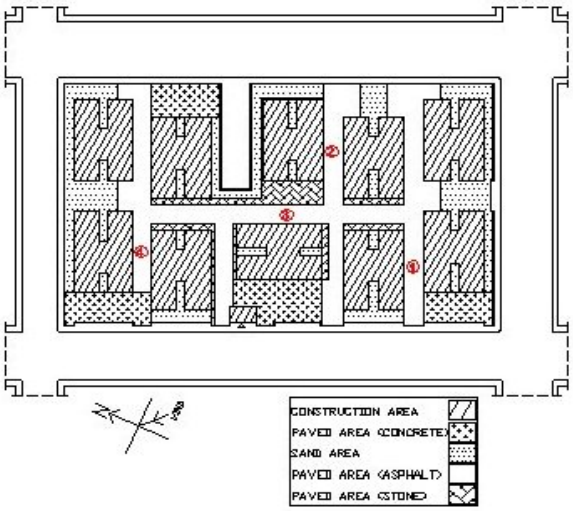

Figure 04: Hebrom Condominium – Situation plan

3.3 The measurements in the exterior areas

In each housing estate were done measurements of air temperature, relative humidity and wind velocity, using a digital termo-hygrometer and a anemometer. The measurements were done at 9:00pm, 03:00pm and 09:00pm, according to the OMM recommendation, at 1,0 m ground distance.

The measurements at Hebrom Condominium were done on the 18th, 21st and 22nd of November and at Santa Marta Condominium, on the 4th , 6th and 7th of November. In each one were chosen 4 and 6 points, respectively, to show the different types of ground covering (figures 03 e 04).

Considering that there is a correlation between every climatic variable analysed, a statistical analysis was applied to the study of the measurements at the housing estates and at the meteorological center.

The analysis showed that the two housing estates have different performances concerning the reference meteorological center, when the climatic elements are compared all together.

When compared individually, the average climatic variables at Santa Marta, are significantly different concerning the air temperature and wind velocity. The relative humidity did not show special differences in relation to the meteorological center (EMBRAPA), as shown in the graphs.

The air temperature graphs shows that the difference, in the morning and at night, among the temperatures found, is about 3ºC, decreasing to 2ºC, approximately, in the afternoon. The housing estate presents low ground occupation tax, only 21,11% with great green area, 46,72% formed by lawn, medium and big trees, shading the ground and allowing a higher relative humidity (figure 05).

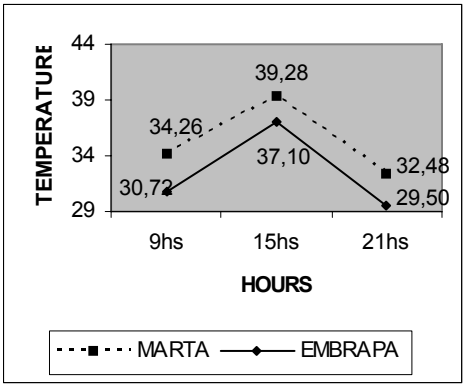

Figure 05: Santa Marta x Meteorological center temperatures

According to the graph (figure 06) the relative air humidity at the condominium is lower in the morning and at night and coinciding at 03:00pm, when were registered the lowest values.

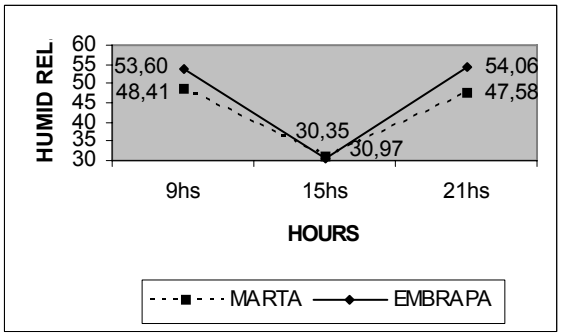

Figure 06: Santa Marta x Meteorological center relative humidity

The winds velocity at Santa Marta is significantly different, as shown in the graph, (fig.07) showing lower values than EMBRAPA. In the condominium open areas, the winds are influenced by the position of the buildings, which modify their velocity and direction.

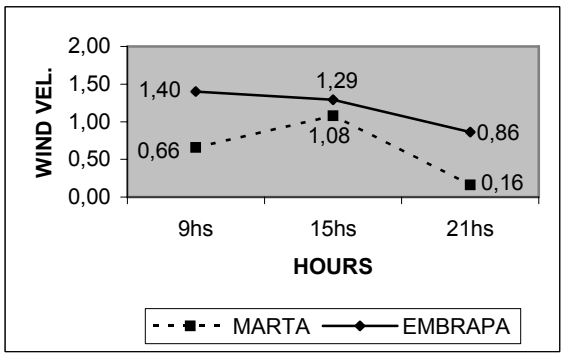

Figure 07: Santa Marta x Meteorological center wind velocity

When compared individually, the average variables at Hebrom Condominium, are significantly different concerning the air temperature. The relative humidity and wind velocity did not show special differences in relation to the meteorological center, as shown in the graphs.

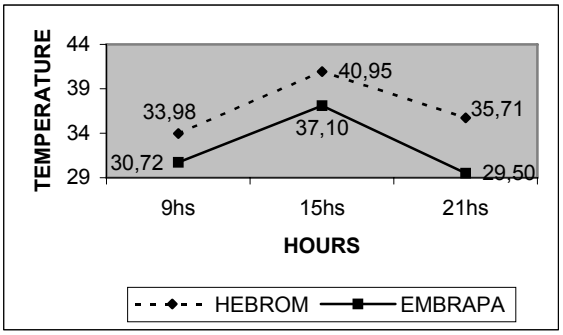

Figure 08: Hebrom x Meteorological center temperatures

The air temperature at Hebrom Condominium (figure 08) is higher than those shown by the reference center, in all hours. This difference is lower in the morning period, when the ground surface covering begins to get hotter and goes up to 6°C higher at night, when the heat accumulated by the surface materials during the day irradiates thermal radiation.

The ground occupation tax in this housing estate is 45,29% and 31,29% of the area is paved with asphalt or cement, material with low albedo that absorb enough sun radiation. The emittance of these materials is about 0,90.

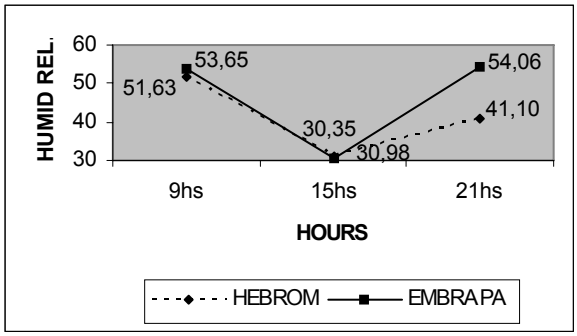

Figure 09: Hebrom x Meteorological station relative humidity

The air relative humidity is almost the same in the morning and in afternoon, as shown in the graph (figure 09). The housing estate humidity at night is smaller, as a result of the small percentage of green area, only 10% of trees and no grass areas.

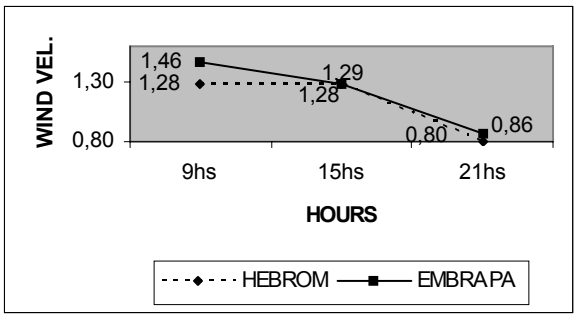

Figure 10: Hebrom x Meteorological station wind velocity

The wind velocity at Hebrom Condominium did not show significant differences, although it is located in an urban area. This fact can be explained due to the buildings proximity (H/W=2,13) which canalizes the winds and increases their velocity.

4. CONCLUSIONS

According to the measurements and the statistics, we can affirm that in both housing estates, the air temperature is different from those registered by the meteorological center of reference, as a result of modifications originated in urban areas by the buildings and the open areas covering. That difference is higher at night and in the housing estate with bigger ground occupation tax and bigger paved ground area, proving the logic of heat islands creation by the excessive covering of urban surfaces.

The relative air humidity, in both researched condominiums did not present significant differences compared to the meteorological center. The relative humidity, at 03:00pm is lower and equal in the three places. During the night, the humidity is lower in the housing estate where there is no grass covering and the ground impermeable tax is bigger, proving, once more, that the surfaces which are more permeable help to decrease the urban heat.

The research showed that there is a relation between the H/W relation and the wind velocity relation. Where the relation is bigger and the open spaces smaller, the wind is canalized and increases its velocity, decreasing the difference with the center in reference. However, the canalization also changed the wind direction, and can decrease the ventilation in the apartments

The research must continue, getting measurements in both hot and humid period, to verify the environmental variables behavior during the whole year and determine design recommendations to housing estates in the tropical continental regions of Brazil.

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