VEGETATION INFLUENCES ON THE HUMAN THERMAL COMFORT IN OUTDOOR SPACES

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ABSTRACT

The purpose of this work is to evaluate the thermal comfort of human beings in outdoor spaces, taking into account the microclimatic modifications produced by vegetation. The parameters needed to formulate a comfort index are of differing orders of magnitude, so the same conditions could be seen as comfortable outdoors and yet be unacceptable indoors. One of the most influential landscape elements in the degree of comfort is vegetation. The main effects of vegetation are on solar radiation and wind. However urban wind is more affected by the configuration of urban development than by vegetation. This paper involves numerical evaluation of outdoor radiation effects. Two Barcelona district case studies are presented. The first deals with a pergola in a landscaped square. The second is a tree-lined street of with east-west orientation. In both cases, measures of the main parameters were taken on a summer day and in winter.

KEYWORDS

Thermal comfort, vegetation, urban microclimate, outdoor spaces, radiation evaluation, microclimatic measurements, urban landscape

INTRODUCTION

One differential characteristic of life in Mediterranean climates is the use of outdoor spaces as inhabitable zones. These spaces are used to reach acceptable comfort levels. However, reaching a feeling of well-being comparable to indoor conditions is not the purpose.

Town and city streets, squares and courtyards traditionally employ various climate control techniques such as pergolas, ponds and fountains, as well as the geometry of the built elements that delimit the space. In addition to these physical characteristics, the vegetation present will also have a considerable effect on the feeling of comfort.

Vegetation influences temperature, humidity, radiation and wind, and it also has an effect on air composition, as well as improving the visual landscape and quality of life. In another publication, Ochoa and Serra (1998), a method for analysing all these factors was presented.

In this paper we have established a calculation method that allows us to estimate the effect of modifications in certain landscape elements, mainly vegetation, on the radiative budget of a 'test person'.

A MODEL FOR THE EVALUATION OF OUTDOOR THERMAL COMFORT

As an evaluation model we have calculated the hourly energy budget (watt/m2) on a test person. First, the model calculates the radiation absorbed by the test person and then the total budget which can be related to his/her comfort. In Table I, the relation between energy budget and comfort levels can be seen; Brown and Gillespie (1995).

TABLE I
Translation of energy budget values into people's confort levels

Budget (w/m2)	Interpretation
Budget < -150	Would prefer to be much warmer
-150<Budget<-50	Would prefer to be warmer
-50<Budget<50	Would prefer no change
50<Budget<150	Would prefer to be cooler
150<Budget	Would prefer to be much cooler

To calculate radiation absorbed by a person instantaneously, we consider values depending on the time of the day (temperature, radiation over horizontal surface and solar elevation) and other values that vary depending on the season of the year, the spatial configuration and the physical properties of the elements that make up the system (Sky View Factor, Albedos of the person, ground and other objects, and the transmissivity of the plant canopy).

To calculate the budget we also consider relative humidity and wind velocity as time-of-the-day dependent variables, and clothing and metabolic rate as season-of-the-year dependent variables.

ANALYSIS OF CASE STUDIES

In this paper we have selected two cases: A square with a pergola (Glicinia) and a street lined with trees (Platanus acerifolia) on both sides. In each case, temperatures (of the air and radiant), radiation over horizontal surface (in the open and under the tree canopy), and relative humidity have been measured. The Beaufort scale has been used to estimate wind velocity. The transmissivity of the vegetation has been calculated from the radiation measures.

We immediately used the model to evaluate the budget of the test person in summer and winter. For the purpose of comparison, we have included a simulation of one hypothetical case without vegetation.

Radiation on horizontal plane, air temperature and the budget have been plotted for each case.

Plaza Mossen Clapés

It is a square located in the district of Sant Andreu in Barcelona. In the central sector, there is a rest zone covered by a deciduous leafed pergola. The pavement under the pergola and its surroundings are made of light concrete with a high albedo. The buildings surrounding the square are approximately 8 storeys high and have dark coloured facades (see figure 1).

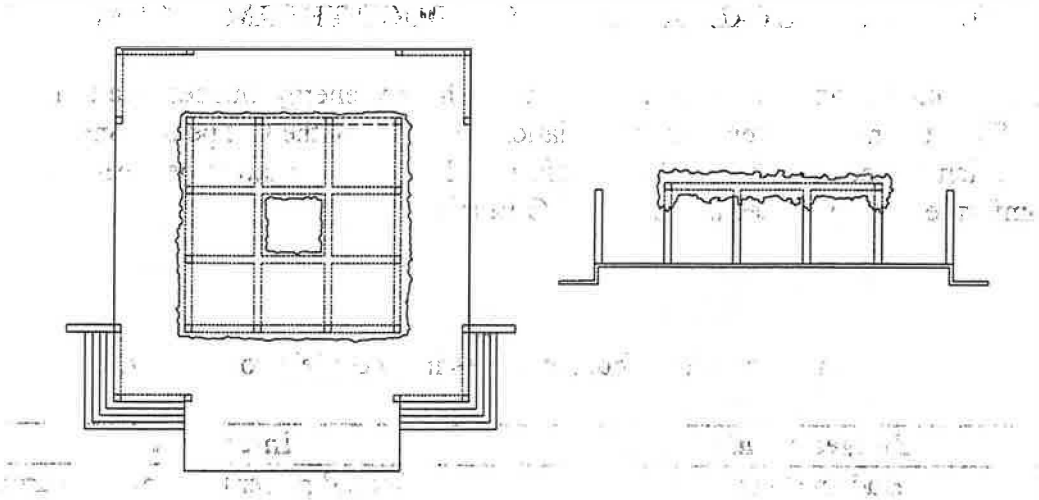

Figure 1: Plant and section of the pergola

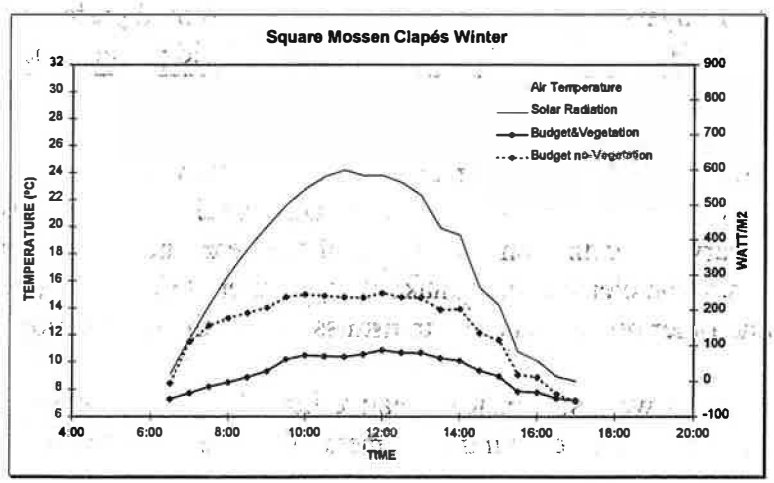

Figure 2: Winter results

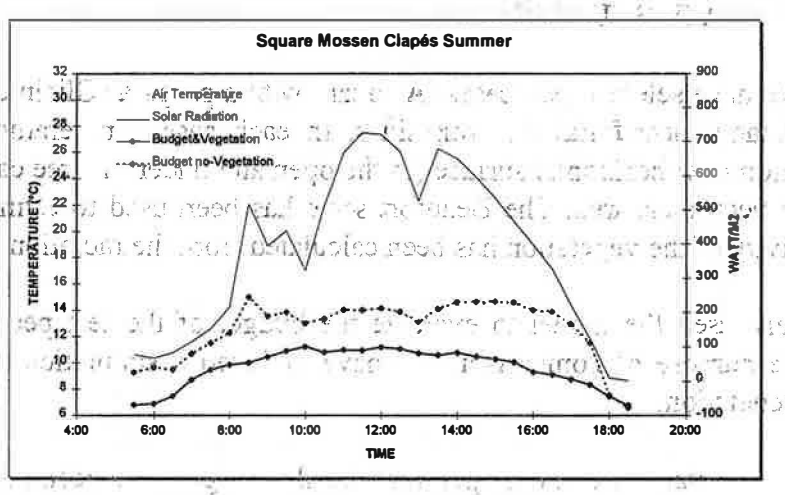

Figure 3: Summer results

Carretera de Sants

It is a street lined with trees on both sidewalks, located in the district of Sants, also in Barcelona. It is a commercial street with moderate-high car traffic. The sidewalks are made of concrete and the roadway is made of dark asphalt. The buildings on the street, which runs in an East to West direction, are 6-storeys high and have dark coloured facades (see figure 4).

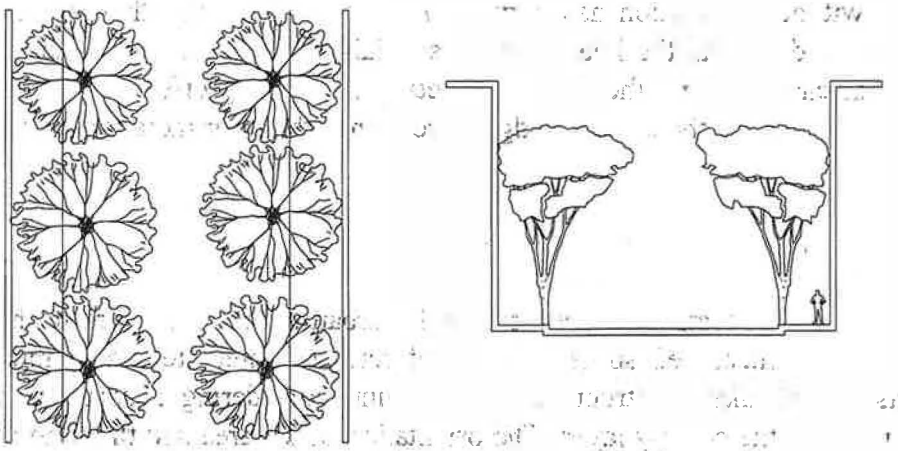

Figure 4: Plant and section of the street

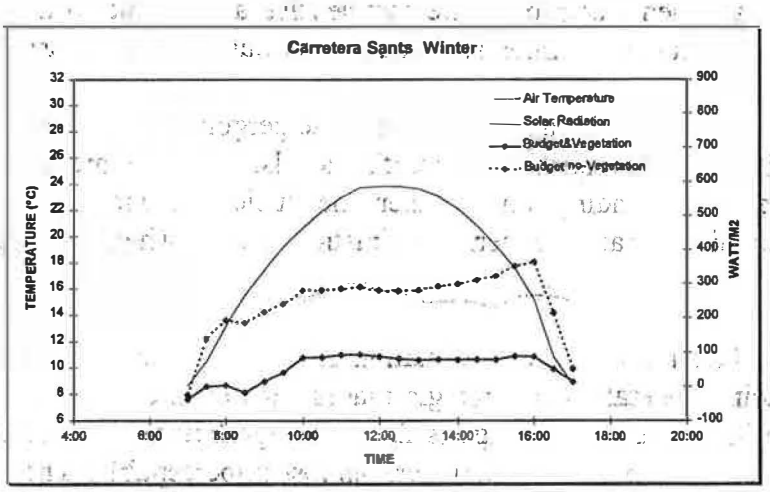

Figure 5: Winter results

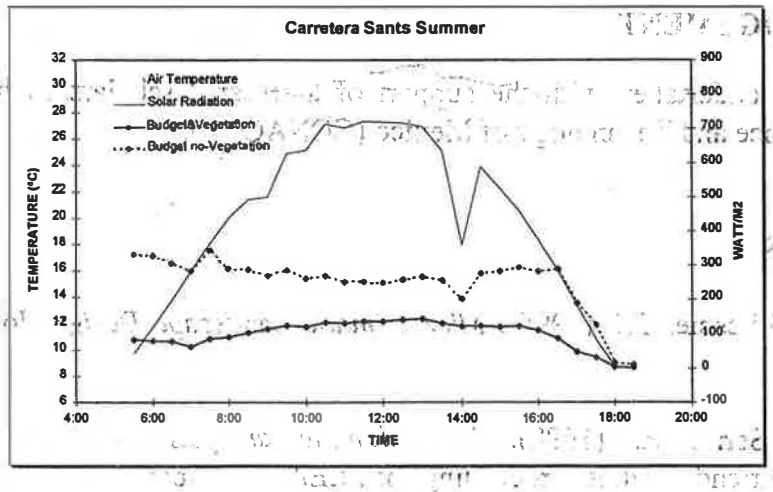

Figure 6: Summer results

DISCUSSION OF RESULTS

In the above figures (2, 3, 5 and 6) the results are shown. The radiation and air temperature of winter show very clear days, with high temperatures for this season. In summer days were slightly cloudy with typical temperatures.

The budget without vegetation has very high values. This is due that the same clothing is considered, so it difficults the heat losses (specially in winter), while radiation's intensity grows. In both cases, during the winter, vegetation's shading effect keep acting in a rather important way, buffering the energy budget, even when the solar radiation changes suddenly.

CONCLUSIONS

As the most evident effects of vegetation on the urban microclimate are in the area of solar radiation, we have measured some of these effects and integrated them into a calculation model. This model takes obstruction into account, considering absorption, reflection and transmission due to the canopy layer. The orientation of the area and the ratio of the height of its boundaries to its width are also accounted for through the Sky View Factor.

The measuring instruments employed are inexpensive and simple to use. Our belief is that every architect or urban planner interested could carry out the same measurements by himself.

One specific conclusion of the paper is that both the pergola and the tree-lined street can play an important role in improving thermal comfort levels. Higrothermic human comfort and its interpretation varies depending on whether the subject is indoors or outdoors. Indoor environmental conditions rarely experience drastic changes, whereas outdoor conditions can fluctuate rapidly.

Another climatic factor affected by vegetation is wind, whose direction and speed can be modified by placing vegetation in strategic places. However, as has been seen, in an urban environment the influence of buildings is far more significant. The effects of vegetation on environmental temperature and humidity are almost imperceptible. These factors are being studied more deeply in a research project dealing with the whole of Cerdà's Eixample district.

ACKNOWLEDGEMENT

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