Revista de Gestão Ambiental e Sustentabilidade – GeAS
Organização: Comitê Científico Interinstitucional/ Editora Científica: Profa. Dra. Cláudia Terezinha Kniess

Recebido: 22/05/2017- Aprovado: 29/06/2018
DOI: https://doi.org/10.5585/geas.v8i1.13762
E-ISSN: 2316-9834

ANALYSIS OF PUBLIC SPACE THROUGH CLIMATIC VARIABLES IN THE CENTRAL AREA OF A CITY IN THE NORTH OF RIO GRANDE DO SUL, BRAZIL

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ABSTRACT

Aim: To diagnose and analyze four main variables of urban ambience in central Passo Fundo, which were temperature, wind speed, humidity and environmental noise.

Methodology: The methodology consisted initially in the definition of three core areas of the city (one with vegetation and two paved). The measurement of the variables was performed in the morning and afternoon shifts, when half the samples was collected in the shade and the other half, with sun exposure. Bioclimatic datasheets for characterization were filled out for each area characterization.

Originality/Relevance: Besides the presented analysis being a proposal within the bioclimatic theory, the evaluation of spaces like squares and streets allows other elements of the local infrastructure to complement and to generate the necessary comfort for all the inhabitants.

Main findings: In the paved areas there is a higher concentration of heat and noise both in the morning and in the afternoon. In addition, the humidity is higher in the area with vegetation and wind measurements did not show a pattern like the other items evaluated.

Theoretical/methodological contributions: The research proved the importance of green areas in the city, both for climate balance and for the existence of points with a better urban environment for the population.

Conclusion: Considering the characteristics of urban ambience in the public space, their importance for comfort and their relationship with urban planning, this study evaluated the existing microclimate in three pre-established locations in the city of Passo Fundo, located in the north of Rio Grande do Sul state, Brazil.

Keywords: Urban ambience. Comfort. Bioclimatic variables.

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ANÁLISE DO ESPAÇO PÚBLICO, POR MEIO DE VARIÁVEIS CLIMÁTICAS, NA ZONA CENTRAL DE CIDADE DO NORTE DO RIO GRANDE DO SUL, BRASIL

RESUMO

Objetivo: Diagnosticar e analisar quatro variáveis principais da ambiência urbana na zona central de Passo Fundo, sendo elas temperatura, velocidade do vento, umidade e ruído ambiente.

Metodologia: A metodologia consistiu, inicialmente, na definição de três áreas centrais da cidade (uma com vegetação e duas pavimentadas). A medição das variáveis foi realizada nos turnos da manhã e da tarde, com metade das amostragens, sendo feitas na sombra e a outra metade com exposição ao sol. Sobre cada área foram preenchidas fichas bioclimáticas para caracterização.

Originalidade/Relevância: Além da análise apresentada ser uma proposta dentro da teoria bioclimática, a avaliação de espaços, como praças e vias permite que outros elementos da infraestrutura local complementem e gerem o conforto necessário para todos os habitantes.

Principais resultados: Nas áreas pavimentadas existe maior concentração de calor e som, tanto no período da manhã, quanto no período da tarde. Além disso, a umidade é maior na área com vegetação e a medição do vento não apresentou um padrão como os demais itens avaliados.

Contribuições teóricas/metodológicas: A pesquisa comprovou a importância das áreas verdes na cidade, tanto pelo equilíbrio climático, quanto pela existência de pontos com melhor ambiente urbano para a população.

Conclusão: Considerando características de ambiência urbana no espaço público, sua importância para o conforto e também sua relação com o planejamento urbano, este trabalho avaliou o microclima existente em três locais pré-estabelecidos na cidade de Passo Fundo, localizada no norte do estado do Rio Grande do Sul, Brasil.

Palavras-chave: Ambiência urbana. Conforto. Variáveis bioclimáticas.

ANÁLISIS DEL ESPACIO PÚBLICO A TRAVÉS DE VARIABLES CLIMÁTICAS EN LA ZONA CENTRAL DE UNA CIUDAD DEL NORTE DE RIO GRANDE DEL SUR, BRASIL

RESUMEN

Objetivo: Diagnosticar y analizar cuatro variables principales de la ambiencia urbana en la zona central de Passo Fundo, como son temperatura, velocidad del viento, humedad y ruido en el ambiente.

Metodología: La metodología se desarrolló, inicialmente, con la definición de tres áreas centrales de la ciudad (una con áreas verdes y dos pavimentadas). La medición de las variables fue realizada en los horarios de mañana y tarde, con la mitad de las muestras tomadas en condición de sombra y la otra mitad con exposición al sol. Para cada área fueron diligenciadas fichas bioclimáticas para su respectiva caracterización.

Originalidad/Relevancia: Además de que el análisis presentado es una propuesta dentro de la teoría bioclimática, la evaluación de espacios como plazas y vías permite que otros elementos

de la infraestructura local complementen y generen la comodidad necesaria para todos los habitantes.

Resultados principales: En las áreas pavimentadas existe mayor concentración de calor y ruido, tanto en el periodo de la mañana como en el de la tarde. En contraste, la humedad es mayor en el área que con vegetación y la medición del viento no presentó algún patrón como los demás factores evaluados.

Contribuciones teóricas/metodológicas: La investigación comprobó la importancia de las áreas verdes en la ciudad, tanto por el equilibrio climático, como por la existencia de puntos con un mejor ambiente urbano para la población.

Conclusión: Considerando las características de ambiencia urbana en el espacio público, su importancia para la comodidad y también su relación con la planeación urbana, este trabajo evaluó el microclima existente en tres lugares preestablecidos en la ciudad de Passo Fundo, localizada en el norte del estado de Rio Grande del Sur, Brasil.

Palabras clave: Ambiencia urbana. Comodidad. Variables bioclimáticas.

1 INTRODUCTION

Cities are composed of multiple public spaces where different activities of interaction between citizens and the space itself occur. When they are of good quality, they foster the social and cultural expression of the community, encourage the development of a strong local economy and favour the health of the inhabitants (Ramlee, Omar, Yunus & Samadi, 2015; Sedesol; ONU – Habitat, 2007). Public spaces evolved according to the city and its society, as reflections of history and urbanism. One can conceptualize public space as the physical and open urban space accessible to all citizens and that allows them to meet and participate in urban life (Perico-Agudelo, 2009; Pradinie, Navastara & Martha, 2016).

According to Ambrizzi (2014), the climate is one of the main characteristics of the environment, which even influences the way of life of those who inhabit a certain area. According to Costa (2003), numerous studies developed by Givoni (1969, 1998, 2000) on the relationship between climate and built environment demonstrate its influence on environmental comfort and outdoor activities. In the public space, variables such as temperature, humidity, wind speed and noise should be analysed taking into account local characteristics, such as occupation, materials, developed and planned activities, and are fundamental to the human comfort zone (Givoni, 1969).

Considering this topic, the present paper aims at diagnosing the microclimate in a densely populated urban area, through a bioclimatic analysis of three areas with different spatial and environmental characteristics in the central zone of Passo Fundo, a city with temperate climate located in southern Brazil. The importance of this study is the lack of research on the bioclimatic aspect in urban centers that results in negative perception of comfort in public spaces by the inhabitants.

1.1 Urban ambience and bioclimatic variables in urban space

The concept of urban ambience encompasses not only the material means in which the public or private space is constructed, but is also related to the behavior that will be generated in individuals. The comfort perceived by citizens in the use of urban spaces is the result of the interaction between climatic variables, physical structures and civic culture. Their evaluation is an important tool for planning new spaces or reshaping the existing ones.

According to Adey et al. (2013), ambience qualifies social life, forms the type of local climate and it is seen as a product that does not exist without individuals. Thus, it is a composition of physical and material characteristics, of the groups that use them and the sense of collectivity, and it has environmental quality by relating material and sensorial issues of the environment with individual and intersubjective perceptions.

Thibaud (2015) focuses less on defining ambience and more on understanding their interrelationships. According to the author, it is the ambience that transforms the purely physical spaces into affective spaces, which can be experienced and better lived. The structure of action of the ambience includes instituting the sensitive as a field of action, composing with affective tones, giving consistency to urban situations, maintaining spaces over time and betting on imperceptible transformations. These ambience operations relate, in one way or another, to the quality of the environments, with physical issues such as sound, air conditioning, ventilation, however not solely with the control of these physical parameters, but also with the valorisation of the means to be better experienced. The new architectural developments seek to improve ventilation variables, solar access and natural light in the interiors of buildings, and consequently the urban ambience. However, changes generated in the urban environment such as wind direction, shade access control and winter sun, may or may not promote a variety of urban activities and pedestrian movement (Schiller, 2000).

According to Johansson, Thorsson, Emmanuel & Krüger (2014), the number of studies on external thermal comfort has been increasing in the last years, in diverse contexts and cultures, which shows the greater preoccupation with the public spaces. This subject is relatively new and complex since external environments are more difficult to analyse than the internal ones. Microclimatic variations tend to be larger and there is also less climate control and issues such as sociocultural adaptation to variations in outdoor use.

These external spaces are influenced mainly by climatic variables, which should be part of urban planning. Solar radiation, air temperature, wind speed and humidity are called by Romero (2001) as the major environmental elements. These make up the climate, whether regional or urban, but are influenced by the materials that make up the urban surface.

In the characterization of urban space, sound is an always present parameter influenced by the above-mentioned factors, besides the topography and vegetation of the place. By definition, it is an elastic disturbance of the environment in which it is produced. In turn, noise is a set of unpleasant and undesirable sounds, often as a result of a subjective perception by the individual (Jiménez, Suárez, 2005; Romero, 2001). The relation between noise and city is addressed by Marchetti and Carvalho (2011), who affirm that the urban centers are subject to continuous sources of noises by periods of time, whose perception can be negative or positive depending on the opinion of the residents and the effects on health. And, moreover, its production by commercial activities, permanent leisure or events in public spaces affects residents indistinctly, and can be detrimental to environmental comfort.

1.2 Microclimate and morphology of urban space

According to Perico-Agudelo (2009), the intense interrelation between microclimate, morphology and public space generates bioclimatic effects on the various environmental variables in these spaces, suggesting to planners the places of well-being for citizens. In a study of Colombian cities, the author justifies its importance, since studies conducted by renowned researchers (Givoni, 2004; Nikolopoulou & Steemers, 2003; Taha, 1997) address public spaces in different latitudes. This situation also applies to other Latin American countries and to Brazil, which have geographical climatic and urbanistic diversity.

In Brazil, there are examples of research made on the analysis of bioclimatic properties, which refer to the capacity of the object under studied to suit the climate in which it is

satisfactorily inserted (Rivero, 1985). Although these works do not always have the same methodology, the climatic and environmental parameters, among other climatic and architectural characteristics, are similar. Most part of these examples of researches aim to improve the environmental and occupational comfort of open spaces, with public squares being the main places of analysis due to their social and cultural function.

Besides these functions, the squares are also the public spaces with the greatest amount of vegetation within the cities. In addition to the importance of conservation, these green areas contribute to the microclimate of the urban environments. Bowler, Buyung-Ali, Knight & Pullin (2010) reviewed a number of studies on the effects of green spaces on the temperature, and the evidence points to their importance in refreshing environments and acting against the effect of heat island, for example.

The local climate changes associated to the use and occupation of the soil are considered microclimatic variations whose main modifying agent are the building materials, because they play a key role in the behavior of temperature and relative humidity (Alves & Biudes, 2011).

1.3 Bioclimatic evaluation and analysis of the public space

Qualitative and quantitative procedures of the climatic parameters and their combinations, and many still consider the perception of the users.

In the city of Natal, the capital of Rio Grande do Norte, a study by Araújo, Caram, Araújo and Dantas (2006), was based on three stages of bioclimatic analysis: qualitative, quantitative and statistical. Thus, the study considered the visual evaluation of the space, the analysis of the values obtained by specialized equipment and the historical record of the variables used. The authors make a comparison between the data of the chosen areas, mainly squares and square beds, concluding where one should improve the architectural structure or increase the green zones. The increase of green areas is especially important given the evidence of mitigation of high urban temperatures with the incorporation of vegetation in public spaces (Nice, Coutts & Tapper, 2018, Shashua-Bar, Potchter, Bitan, Boltansky & Yaakov, 2010; Tsiros, 2010).

The study of Costa (2003), in the district of Petrópolis de Natal, RN, uses a methodology that combines methods of bioclimatic analysis of Oliveira (1993), considering more the perception of the users proposed by Romero (2001). Similar methodology was applied by Carvalho (2005) in a study related to bioclimatic analysis with tool for implementation of the University Campus Master Plan in the same municipality.

The work developed by Pantaleão and Romero (2008) presents the methodology proposed by Romero (2001). Evaluation on a sidewalk in the city of Londrina, PR, using a form that records the characterization of space in relation to environmental and climatic perception in three different levels: the ssurroundings, the base and the border. This qualitative record, combined with microclimatic measurements, enables an approach to a bioclimatic conception of public spaces (Miyamoto, 2011). Likewise, investigations carried out by Vasconcelos and Zamparoni (2011) and by Alves and Biudes (2011) deal with microclimate assessments in the city of Cuiabá (MT). The thermal and hygrothermal contrasts of the urban environment of Aracaju (SE) are treated by Anjos (2012) focusing on topoclimatic contrasts in the intra-urban space that suggest the formation of heat islands.

For the characterization and evaluation of the public space, Romero (2001) proposes two macrocategories: the environment and the space. Thus, within the environmental component, the responses to the action of the four main elements of the urban climate are described: light, wind, humidity and sound. Within the spatial component, the author characterizes three categories: the surroundings, understood as the most immediate urban space;

the base, which corresponds to the horizontal base on which the public space in question is based; and the border surface, seen as the vertical boundary of architectural space.

These macro and subcategories are thematically synthesized in the analytical sheet - Bioclimatic data sheet of the public space - proposed by Romero (2001) to record empirically the survey of sensitive data to space. In addition to the authors cited above, this methodology was applied by Costa (2003) and Carvalho (2005).

2 MATERIAL AND METHODS

The study has a qualitative-quantitative approach, based on the quantitative evaluation of the climatic variables and a qualitative discussion about the evaluated areas.

2.1 Area of study

The study was developed in Passo Fundo, in the northern region of Rio Grande do Sul, as shown in Figure 1. The municipality had an estimated population of 196,739 inhabitants in 2015 and a territorial area of 783.42 km² (Instituto Brasileiro de Geografia e Estatística, 2015). The municipality belongs to the Region of Functional Planning 9 of Rio Grande do Sul, located to the north of the state. Passo Fundo is one of the poles, mainly due to its importance in terms of institutional, health and infrastructure equipment (Secretaria de Planejamento, Gestão e Participação Cidadã, 2015).

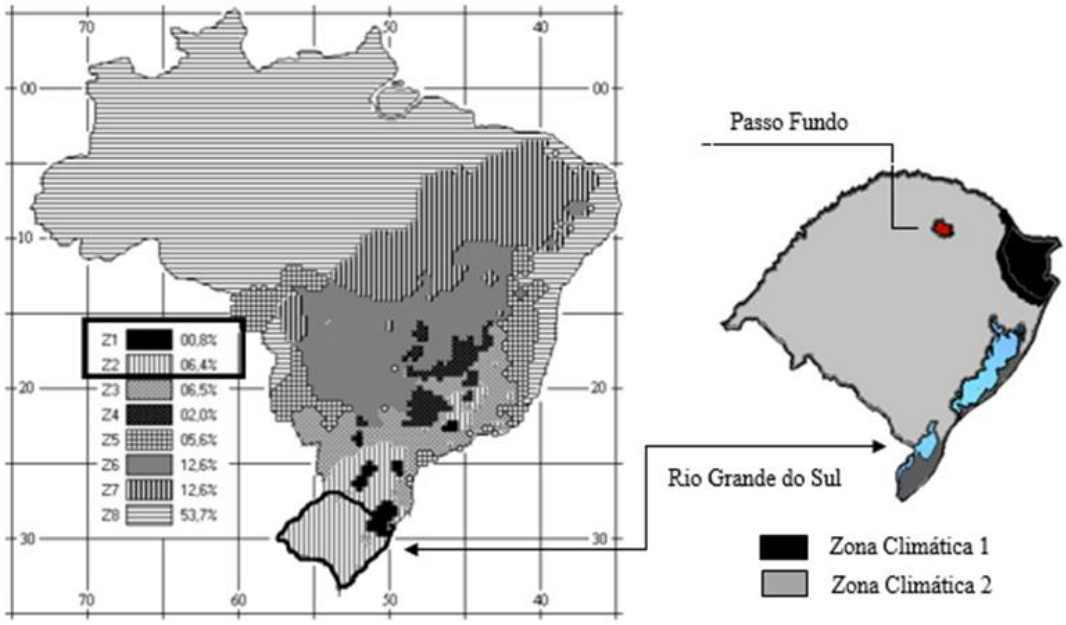


Figure 1 –Geographical location of the municipality of Passo Fundo in the north of the state of Rio Grande do Sul
Source: Prepared by the Authors based on Associação Brasileira de Normas Técnicas (2003).

At an altitude of 687 m above sea level, Passo Fundo has a temperate climate with humid subtropical characteristics and an average annual temperature of 17.5º C, with the average temperature of the hottest month (January) reaching 22.9º C and the average temperature of the coldest month (June) reaching 12.7º C, with relative air humidity (annual average) of 72% (Melo & Romanini, 2007).

The municipality is located in the Bioclimatic Zone 2 (ABNT, 2003), where the local climate is described as humid subtropical (Cfa), with well distributed rain during the year (no

month less than 60 mm) and average temperature of the hottest month higher than 22°C. Similar to the rest of the state of Rio Grande do Sul, it presents well characterized seasons, with hot summer, cold winter and autumn colder than spring. As for rainfall, it presents approximate average overall annual of 1,700 mm, with variation between 79 and 140 days with rain, presenting frost occurrence. The average relative air humidity is between 67% and 76% and the average wind speed is 4.0 m/s with a predominant Northeast direction (Brazilian Agricultural Research Company-Embrapa, 2016).

2.2 Methodology

2.2.1 Selection of the areas of analysis

The central neighbourhood of the city was selected for this study, because it presents a high density of buildings in height, paved roads with great waterproofing by the asphalt pavement and contains green area (central square) with significant vegetation, that is, it presents peculiar urban characteristics which influence the modification of the microclimate. The selection criterion was the intense movement of the place, used as a leisure area by the population, mainly due to the existence of a square, besides being also the historical center of the city, very busy by trade. Three areas were evaluated in this region, shown in Figure 2.

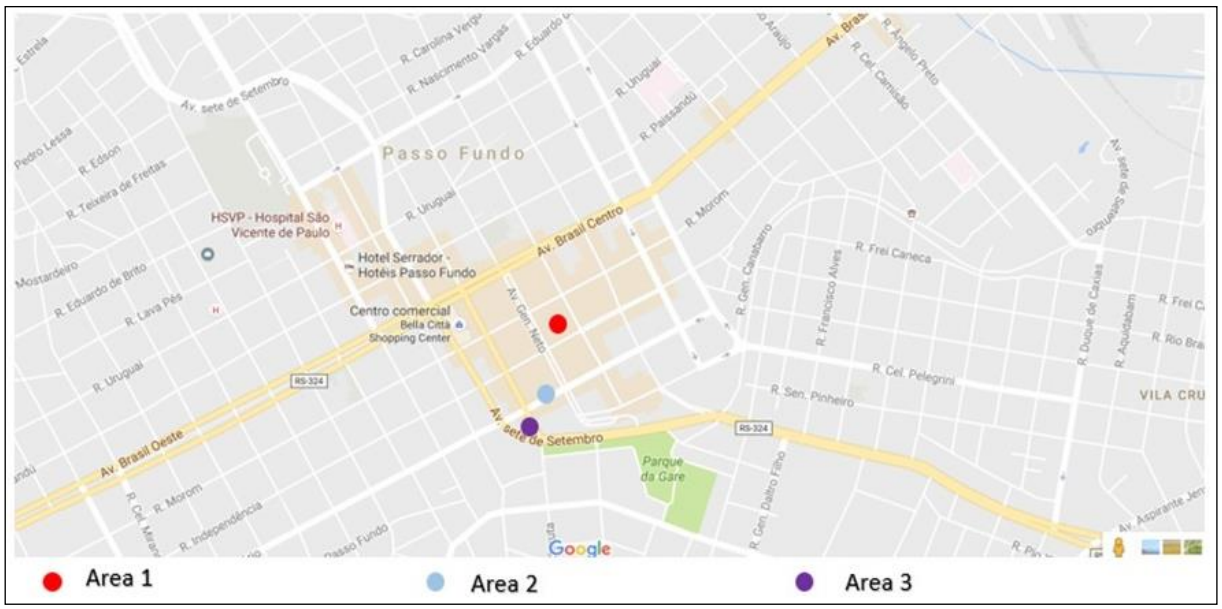
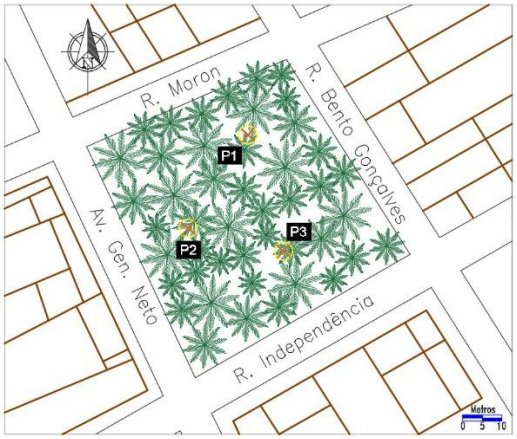


Figure 2 – Location of the studied areas in the central area of Passo Fundo
Source: Google Inc. (2015).

The delimitation of these areas was made based on the assumption that the study should have one unpaved and shaded site, wooded, and other paved spots, being evaluated in two situations, in sun exposure and in shadow, to verify possible variations.

In each one of the chosen areas, three points were defined to measure the variables, in order to obtain the average for each site. Table 1 shows the Study Area 1 with the three points for data collection; in the Study Areas 2 and 3, as streets, the points were distributed linearly, one at the beginning of the block, another in the middle and the last one at the end of the block.

Table 1 – Study Areas and the points for data collection

Area 1 - Praça Marechal Floriano (square) Block delimited by the streets Independência, Bento Gonçalves, Moron and Avenida General Neto, coordinates 28° 15' 45.71" S and 52° 24' 23.31" W. Shaded predominance, paved and unpaved floors.	
Area 2 - General Osório Street Block between General Neto Avenue and Coronel Chicuta Street, coordinates 28° 15' 53.32" S e 52° 24' 24.29" W. Street with exposure to sun and shade and paved.	
Area 3 – Coronel Chicuta Street Block between General Osório Street and Sete de Setembro Avenue, coordinates 28° 15' 55.62" S e 52° 24' 25.68" W. Street with exposure to sun and shade and paved.	

Source: Based on Google Inc. (2015).

2.2.2 Application of the qualitative analysis through the bioclimatic sheet

According to the methodology proposed by Romero (2001), the qualitative analysis was performed using the bioclimatic data sheet, which consists of a qualitative analytical form of

the public space inserted in the urban context, which allows the organization of data in a systematic way. In this material, the spatial elements and the environments are grouped thematically, there being among them a correlation by the characteristics of the surroundings, the base and the border surface.

Spacial			Environmental		
SURROUNDINGS	ACCESS	SUN	COLOR SENSATION		COLOR
		WIND	RESONANCE OF THE ENCLOSURE		SOUND
		SOUND	DIRECT	RADIATION	WEATHER
			DIFFUSED		
			REFLECTED		
	CONTINUITY OF MASS		RELATIVE HUMIDITY		
	WIND DIRECTION		AIR TEMPERATURE		
			WIND SPEED		
BASE	BASE AREA		SURFACE TEMPERATURES		
			LIGHT REFLECTION		
	COMPONENTS AND PHYSICAL PROPERTIES OF THE MATERIALS	PAVEMENT	SOUND ENVIRONMENT		SOUND
		VEGETATION	SEASONAL VARIATION		COLOR
			COLOR SET		
		WATER	TONALITY		
		URBAN FURNITURE	SPOTS OF LIGHT		LIGHT
			AESTHETIC OF THE LIGHT		
BORDER	CONVEXITY		LUMINANCE		
	SURFACE CONTINUITY		INCIDENCE OF LIGHT		
	ARCHITECTURAL TYPOLOGY		FLOW DIRECTION		
	OPENINGS		ABSORPTION		WEATHER
	TENSION		REFLECTION		
	ARCHITECTURAL DETAILS		MATRIXES		COLOR
	NUMBER OF SIDES		CLARITY		
	HEIGHT		ACOUSTICAL PERSONALITY		SOUND
	TOTAL AREA		SURFACE QUALITY OF MATERIALS		

Figure 3 – Bioclimatic sheet for the analysis of the public space
Source: Romero (2001).

The surrounding is characterized by lighting, ventilation and noise conditions, being the most immediate understanding of urban public space. The base includes analysis of the pavement, vegetation and urban furniture; and the border corresponds to the space that forms the boundary of the evaluated architectural space, including convexity, building typology and continuity (Romero, 2001). The bioclimatic record was filled out for the qualitative description of the three chosen areas, based on the close observation of the researchers, using a photographic camera, tripod and the bioclimatic data sheet and pen (Figure 3).

2.2.3 Measurements of bioclimatic aspects

In order to carry out the characterization and analysis of urban ambience of the areas in the center of Passo Fundo in the qualitative analysis, different measurement structures were planned for the four bioclimatic aspects at each of the defined points.

To measure the sound intensity in decibels (dB), 30 readings were taken, one every 5 seconds, using the Sonometer SL-4011 (Instruthermerm), arranged on a tripod for less interference.

For the measurement of temperature, humidity and wind speed, 5 readings were taken every 10 seconds using the THAR-185 Hygro-emitter (Instruthermerm) to measure relative humidity percentage, temperature in ° C and wind speed in m/s.

The measurements were carried out in a single day, at the end of November, which is a month in which temperature and humidity averages similar to the annual climatological norm for the Passo Fundo meteorological station are observed. The average, minimum and maximum annual temperatures for the city are 17.7 °C, 13.2 °C and 23.6 °C, respectively, and in November the values are 19.6 ° C, 14.8 ° C and 26.0 °C (Embrapa, 2017), indicating variations close to 10%. Thus, as a pilot study on the urban microclimate, the measurements performed on the analysed day in the spring season present results that served as approximate indicative of the average annual thermal behavior. Due to the temporal limitation of the study and the points of measurements, the results can be taken as representative of the application of the methodological procedures of analysis regarding the different constructive morphologies, presence of vegetation and pavement types, however only as indicative for microclimate performance in the period of spring season.

3 RESULTS AND DISCUSSION

3.1 Bioclimatic description of the public space

For each one of the chosen areas within the city of Passo Fundo, a bioclimatic description of the public space was made according to the bioclimatic form. Tables 2 and 3 present the main characteristics of this evaluation, spatial and environmental, respectively.

Table 2 – Summary of the spatial bioclimatic assessment in the central area of Passo Fundo

Area	Surroundings	Base	Borders
Area 1- Marechal Floriano square	Exposure and homogeneous lighting, mostly shaded. The place has a moderate to high sounding sensation.	Predominantly permeable, large amount of vegetation, and some impermeable areas formed by the paths inside the square.	Buildings are observed with heights between 3 and 15 floors, emphasizing the presence of the Cathedral Nossa Senha Aparecida.
Area 2 – General Osório Street	Exposure and homogeneous lighting. There is considerable noise disturbance due to street intersections and the location of traffic lights.	Its base is totally waterproof. The variables of temperature and relative humidity are similar to those of the surrounding.	On its border there are buildings with heights between 3 and 10 floors, with few architectural details.
Area 3 – Coronel Chicuta Street	Exposure and homogeneous lighting. There is considerable noise disturbance due to the intersections of the street and the location of traffic lights.	Fully waterproof base. The surface temperature is high due to the paving material.	Buildings with heights of up to 4 floors are observed, with varied architecture between new and old.

Source: Prepared by the Authors based on Carvalho (2005).

Table 3. Summary of the environmental bioclimatic assessment in the central area of Passo Fundo

Area	Surroundings	Base	Borders
Area 1- Marechal Floriano square	Predominance of intense green by local vegetation, relative humidity greater than the surrounding, wind speed accentuated.	Noisy sound environment, receives external sounds from the streets. Palette of green, light colors, shadows generated by the vegetation.	Low absorption due to the microclimate of the square. Predominance of gray and blue hues. Hard materials and large heat emitters.
Area 2 – General Osório Street	The gray color predominates, coming from the asphalt and the buildings. Direct and abundant radiation	Very noisy sound environment, high surface temperatures, presence of multiple shadows formed by buildings.	Incidence of light, direct and indirect. High absorption by street materials. Heat-emitting materials.
Area 3 – Coronel Chicuta Street	Gray color predominates on asphalt and buildings. Abundant and diffuse direct radiation in scarcecondition.	Sound environment very noisy. Set of colors in different gray variations. Presence of shadows formed by buildings.	Direction of light flow perpendicular to the avenue. Uniform brightness according to the side of the road. Acoustic personality varied according to traffic lights.

Source:Prepared by the Authors based on Carvalho (2005).

Figures 4, 5 and 6 present the main characteristics of the three sites analysed for the bioclimatic description of the central zone of Passo Fundo.

Figure 4 – Study Area 1 - Praça Marechal Floriano (square)
Source: Authors.

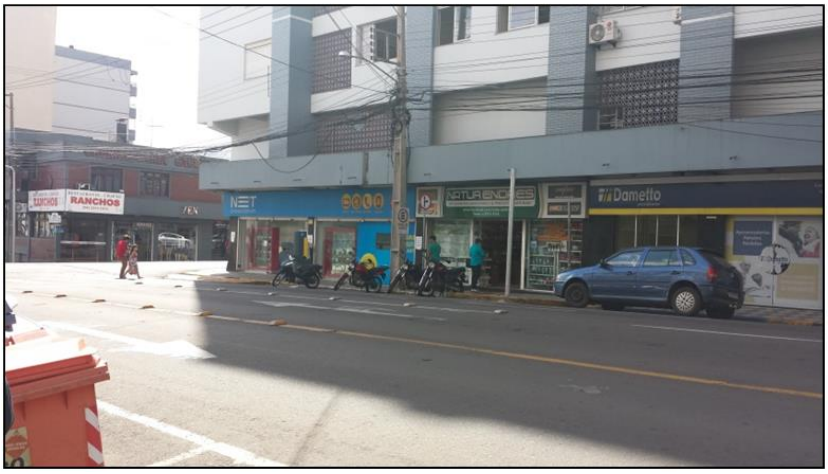


Figure 5 – Study Area 2 - Street General Osório
Source: Authors.

Figure 6 – Study Area 3 - Street Coronel Chicuta
Source: Authors.

3.2 Assessment of the bioclimatic variables

Tables 4, 5 and 6 present the average results of the measurements of the bioclimatic variables evaluated.

Table 4 – Measurements in area 1 - Marechal Floriano square

	Morning			
	Temperature	Humidity	Wind	Noise
Average	(°C)	(%)	speed (m/s)	(dB)
	21.01	75.69	1.21	57.03
	Afternoon			
	Temperature	Humidity	Wind	Noise
Average	(°C)	(%)	speed (m/s)	(dB)
	27.69	58.45	1.01	57.92

Source: Authors.

Table 5 – Measurements in area 2 – Street General Osório

	Morning			
Average	Temperature (°C)	Humidity (%)	Wind speed (m/s)	Noise (dB)
	24.25	66.69	1.07	63.93
	Afternoon			
Average	Temperature (°C)	Humidity (%)	Wind speed (m/s)	Noise (dB)
	29.23	52.58	1.34	64.17

Source: Authors.

Table 6 – Measurements in area 3 – Street Coronel Chicuta

	Morning			
Average	Temperature (°C)	Humidity (%)	Wind speed (m/s)	Noise (dB)
	28.24	56.28	1.76	63.78
	Afternoon			
Average	Temperature (°C)	Humidity (%)	Wind speed (m/s)	Noise (dB)
	33.83	46.78	1.18	64.56

Source: Authors.

3.2.1 Analysis of temperature

In area 1, the average temperature in the morning was 21.01°C, and in the afternoon it was 27.69°C, with an increase of about 30%. In area 2, the average temperature in the morning was 24.25°C, and in the afternoon it was 29.23°C, representing a 20% increase. And area 3 had an average temperature of 28.24°C in the morning and 33.83°C in the afternoon, indicating an increase of approximately 20% as well.

It is observed that the paved areas, 2 and 3, despite having higher temperatures than the wooded area 1, presented a smaller percentage of increase. Yet, despite the greatest increase in temperature in the square, considering the morning and afternoon shifts, it was the area with the best temperature condition for comfort, due to the lower values.

On the day the measurements were taken, the average temperature in Passo Fundo was 20°C, with a maximum of 28°C and a minimum of 15.5°C, according to the local Embrapa weather station. It is noticed that all measured temperatures are above the average temperature, but considering that the highest temperatures were obtained in the afternoon shift, it is acceptable to consider the maximum temperature on this day. In this case, the paved areas exceed this maximum temperature, while the square is close to this maximum value.

3.2.2 Analysis of relative humidity

The humidity data in area 1 were 75.69% in the morning and 58.45% in the afternoon, indicating a reduction of 17%. In area 2, morning humidity was 66.69%, while in the afternoon it was 52.58%. This change indicates a reduction of 14%. Finally, in area 3, the humidity during

the morning measurements was 56.28%, and in the afternoon, 46.78%, indicating a reduction of approximately 9.5%.

It is observed that, as well as the temperature, the humidity presented variation from area to area, being greater in the square and smaller in the paved areas. However, although area 3 presented the highest temperature, it was the place that presented the lowest percentage reduction of humidity between the analysed sites.

The relative humidity of Passo Fundo was 78% on the day of measurements, according to the local Embrapa Trigo weather station, which is located in a rural area. This characteristic is in agreement with the values of humidity observed during the morning in the square, whereas in all the other areas and shifts, such humidity is inferior to the average of the city, essentially due to the characteristics of the surroundings.

3.2.3 Analysis of wind speed

In area 1, the average morning and afternoon wind speed was the same, having a value of 1.28 m/s, however this situation only occurred in this area. In area 2, the morning speed was 1.76 m/s, and in the afternoon it had a 54.4% reduction, with a value of 0.82 m/s. Finally, area 3 presented in the morning the highest speed of the study, with a value of 2.24 m/s, which was reduced in the afternoon measurement by 35.7%, with a value of 1.44 m/s. The average for the three areas was 1.76 m/s in the morning and 1.18 m/s in the afternoon, which would be the average values of the city center at each time of day.

It can be observed that the unpaved area, the square, has a more stable wind than the other two; likewise, the wind velocity in the square was lower than in the paved areas, which is probably due to the presence of vegetation, which is more representative within its base. On the other hand, in the morning hours a wind velocity was almost twice greater in the two paved areas, which generated a descending general wind average to the center of the city.

According to the Embrapa's wind characterization report made at its weather station Trigo, from 1977 to 1994, the average wind in Passo Fundo for November was 4.3 m/s. However, all the values obtained by the study group are smaller, regardless of the time of the day. The average did not exceed 2 m/s, which would represent less comfort for the city in case of very high temperatures. The classification of this wind speed according to the Beaufort scale was "Light Breeze", which is almost imperceptible for people.

3.2.4 Analysis ofthe surrounding noise

In the assessment of area 1, the value of 57.03 dB was obtained in the morning and 57.92 dB in the afternoon, and an increase of 1.56% between the two measurement times was observed. For area 2, the measurements showed in the morning the sound emission of 63.93 dB and 64.17 dB in the afternoon, where it is observed that in the second measurement there was an increase of 0.38% in the intensity of the sound. In area 3, the measurements show that in the morning the sound emission was 63.78 dB and in the afternoon 64.56 dB, evidencing an increase of 1.22%.

It can be observed that the paved areas 2 and 3 present higher surrounding noise, but with a smaller difference between the measurement times. The area 1 (square) presented a lower value, but the variation presented between the first measurement and the second one was larger.

Sound measurements were taken on a Tuesday when the flow of people and cars could be considered a normal day of transit in the city. In area 1, the intensity of the automotive sounds is minimized by the trees surrounding the square and the other sounds captured by the device were apparently mixed with the sound emitted by the vehicles.

In areas 2 and 3, the noise emitted by the people was less perceptive and the sound of the automobiles had more predominance, since they were the paved areas where there were intersections between the streets, traffic lights and bus stop.

In all the analysed points, the measurements presented values higher than 55 dB, the recommended value by the World Health Organization and above 60 dB established by NBR 10151, for mixed areas, with commercial and administrative vocation, in the daytime schedule, according to Table 7. It is observed that even the areas of low sound intensity present numbers that are outside the standards considered appropriate for health. In this way, it is evident that the paved areas present greater intensity of surrounding noise in relation to the unpaved area.

Table 7 – External noise assessment rating level (in Db)

Areas	Daytime	Night
Areas of Ranches and Farms	40	35
Strictly residential urban area or of hospitals and schools	50	45
Mixed, predominantly residential area	55	50
Mixed area, with commercial and administrative vocation	60	55
Mixed area with recreational vocation	65	55
Predominantly industrial area	70	60

Source: Adapted from Associação Brasileira de Normas Técnicas (2000).

As a recommendation for noise attenuation, behavioral and educational measures such as civility and population awareness can be used to reduce noise emission, by noise restrictive legislation (Marchetti & Carvalho, 2011). From the traffic point of view, it requires control and change of the variables of total vehicle flow, average speed and percentage of heavy vehicles at intersections (Nunes, 1999). In the road infrastructure, smoother and well-maintained pavements can be used, which influence road noise emission due to lower friction with vehicle tires, such as asphalt (Nunes, 1999) or high acoustic absorption (Instituto do Ambiente, 2004).

Likewise, vegetation can help reduce noise if there is a strategic location of green areas (Carvalho, 2005). An area of dense trees at 10 m from the source and a width of 20 m shall be required for every 2 dB at 1 kHz. When grass is dense and there is foliage in the soil, this attenuation may increase to 4 dB. Even offering little attenuation due to the area it occupies, vegetation can serve as a visual barrier, causing a more favorable psychological effect on the recipient (Nunes, 1999).

4 CONCLUSIONS

The present study evaluated the characteristics of urban ambience on a qualitative and quantitative scale. At the qualitative level, the bioclimatic record of public space shows that the perception of comfort in the environmental and spatial category is greater in area 1 - Marechal Floriano Square. Its conditions of shading, color, wind conduction, aesthetics of light and even urban furniture make it a pleasant environment for those who use this urban space. However, it is observed that the perception of comfort is greater in the surroundings and at the base of the place, since at the border the levels of radiation, acoustic personality and irregularities in the architectural typology vary.

In study areas 2 and 3, the qualitative record presented a similarity in the different urban ambience variables. Acoustic disturbance predominates due to crossroads and the great flow of traffic. In addition, a greater incidence of light and solar radiation was perceived in the surroundings, base and border of the place. In the environmental category, the set of colors, the tonality and surface quality of the materials, negatively affect the climatic variables.

At the quantitative level, the data corroborate the empirical record made. The analyses showed that in the green area, the Marechal Floriano Square, the temperatures were always lower and the humidity was higher, reducing the thermal amplitude, both in the morning and in the afternoon. This is translated as a better level of comfort, and the vegetation is a very important factor for this characteristic. The paved areas and their characteristics of the surroundings favor microclimates warmer and of lower quality for those who use it, as evidenced by the high temperature values. However, wind flow through the streets is greater, both in the qualitative record and in the quantification performed *in situ* through the wind speed values. This characteristic may be important for the generation of better levels of comfort in waterproof spaces and with high sun exposure, without the possibility of large green areas.

In this way, it was verified the existence of variations in the microclimate of the analysed area, and based on the studied literature, it can be attributed to the different materials of coverage of the floor and to the typologies and barriers of the built surrounding.

Regarding urban noise, it was verified that the levels of sound emitted by the vehicles during the analysed days in the central area of the city of Passo Fundo are at levels considered to be harmful to health. The values presented were measured outside the peak hours and this shows that, in a more in-depth analysis, the values can become more expressive and, in this way, it is perceived that the comfort areas related to sound within the urban environment are increasingly reduced.

In the square, lower values of noise were expected, due to the functions that this environment should perform in the city, but this was not so evidently observed, because this space is in an environment of high flow of people and vehicles, being passage crossing point to pedestrians and merchants.

In general, the work proved the importance of green areas in the city, both for climate balance and for the existence of points with a better urban ambience for the population. In areas of commercial and recreational use, a percentage of green areas could be recommended for each square meter of paved area, in order to improve not only the general conditions of the place, but also the perception of community comfort.

Besides the presented analysis being a proposal within the bioclimatic theory, the evaluation of spaces like squares and roads allows other elements of the local infrastructure to complement and to generate the necessary comfort for all the inhabitants.

REFERENCES

Ambrizzi, T. (2014). *Variabilidade e mudança no clima: passado, presente e futuro*. Mudanças climáticas: do global ao local (pp. 1-38). Barueri: Manole.

Adey, P., Brayer, L., Masson, D., Murphy, P., Simpson, P., & Tixier, N. (2013). 'Pour votre tranquillité': Ambiance, atmosphere, and surveillance. *Geoforum*, 49, 299-309.

Alves, E. D. L., & Biudes, M. S. (2011). Os microclimas da Universidade Federal de Mato Grosso/Cuiabá. *Raega - O Espaço Geográfico em Análise*, *23*, *600-620*.

Anjos, M. W. B. (2012). *Ambiente urbano: contrastes térmicos e higrométricos espaciais em Aracaju-Sergipe (Brasil)*. Dissertação de mestrado, Universidade de Coimbra, Coimbra, Portugal.

Araújo, B. C. D., Caram, R. M., Araújo, V., & Dantas, M. (2006). Análise bioclimática em centro histórico. *Anais do Encontro Nacional de Tecnologia no Ambiente Construído*, Florianópolis, SC, Brasil.

Associação Brasileira de Normas Técnicas. (2000). *NBR 1051: Acústica - Avaliação do ruído em áreas habitadas visando o conforto da comunidade - Procedimento*. Rio de Janeiro: ABNT.

Associação Brasileira de Normas Técnicas. (2003). *NBR 15220: Desempenho térmico de edificações - Parte 3: Zoneamento bioclimático brasileiro e diretrizes construtivas para habitações unifamiliares de interesse social*. Rio de Janeiro: ABNT.

Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and urban planning*, 97(3), 147-155.

Carvalho, S. O. (2005). *Análise bioclimática como ferramenta para implementação do Plano Diretor do Campus Central da UFRN*. Dissertação de mestrado, Universidade Federal do Rio Grande do Norte, Natal, RN, Brasil.

Costa, A. D. L. (2003). *Análise bioclimática e investigação do conforto térmico em ambientes externos: uma experiência no bairro Petrópolis em Natal, RN*. Dissertação de mestrado, Universidade Federal do Rio Grande do Norte, Natal, RN, Brasil.

Empresa Brasileira de Pesquisa Agropecuária. *Clima de Passo Fundo*. Recuperado em 28 setembro, 2016, de http://www.cnpt.embrapa.br/pesquisa/agromet/pdf/Clima_de_Passo_Fundo.pdf

_____. Embrapa Trigo. Laboratório de Agrometeorologia. Informações meteorológicas: normais climatológicas Passo Fundo. Recuperado em 28 agosto, 2017, de http://www.cnpt.embrapa.br/pesquisa/agromet/app/principal/normais.php

Givoni, B. (1969). *Man, Climate and Architecture*. Amsterdam: Elsevier Publishing Company Limited.

Google Inc. (2015). Google Earth. Versão 7.1.5.1557. Google Inc..

Google Inc. (2015). Google Maps. Google Inc.

Instituto Brasileiro de Geografia e Estatística. (2005). *Cidades*. Recuperado em 4 dezembro, 2015, de http://www.ibge.gov.br/cidadesat/topwindow.htm?1

Instituto do Ambiente. (2004). Ministério das Cidades, Ordenamento do Território e Ambiente. *O ruído e a cidade*. Lisboa.

Jiménez, A. M., & Suárez, P. M. (2005). El ruido ambiental urbano en Madrid. Caracterización y evaluación cuantitativa de la población potencialmente afectable. *Boletín de la Asociación de Geógrafos Españoles*, 1(40), 153-179.

Johansson, E., Thorsson, S., Emmanuel, R., & Krüger, E. (2014). Instruments and methods in outdoor thermal comfort studies–The need for standardization. *Urban Climate*, 10, 346-366.

Marchetti, M. C., & de Carvalho, M. S. (2011). Ruídos na Cidade de Londrina–Paraná, Brasil. *Raega-O Espaço Geográfico em Análise*, *23*, *621-651*.

Melo, E. F. R. Q., & Romanini, A. (2007). A Gestão da Arborização Urbana na Cidade de Passo Fundo/RS. *Revista da Sociedade Brasileira de Arborização Urbana*, *2*(1), 1-16.

Miyamoto, M. T. (2011). *A influência das configurações urbanas na formação de microclimas: estudo de casos no município de Vitória-ES*. Dissertação de mestrado, Universidade Federal do Espírito Santo, Vitória, ES, Brasil.

Nice, K. A., Coutts, A. M., & Tapper, N. J. (2018). Development of the VTUF-3D v1. 0 urban micro-climate model to support assessment of urban vegetation influences on human thermal comfort. *Urban Climate*, https://doi.org/10.1016/j.uclim.2017.12.008

Nikolopoulou, M., & Steemers, K. (2003). Thermal comfort and psychological adaptation as a guide for designing urban spaces. *Energy and Buildings*, *35*(1), 95-101.

Nunes, M. F. O. (1999). Poluição sonora em centros urbanos: o ruído de tráfego veicular. *Anais do Encontro Nacional de Engenharia de Produção*, de http://www.abepro.org.br/biblioteca/ENEGEP1999_A0068.PDF

Pantaleão, S. C., & Romero, M. A. (2008). Análise do espaço urbano: O calçadão de Londrina. *Seminario Internacional Nutau*, São Paulo, SP, Brasil, 7.

Perico-Agujelo, D. (2009). El espacio público de la ciudad: una aproximación desde el estudio de sus características bioclimáticas. *Quadernos de vivienda y urbanismo*, 2(4), 278-301.

Pradinie, K., Navastara, A. M., & Martha, K. E. (2016). Who's Own the Public Space?: The Adaptation of Limited Space in Arabic Kampong. *Procedia-Social and Behavioral Sciences*, *227*, 693-698.

Ramlee, M., Omar, D., Yunus, R. M., & Samadi, Z. (2015). Revitalization of urban public spaces: An overview. *Procedia-Social and Behavioral Sciences, 201*, 360-367.

Rivero, R. (1985). *Arquitetura e clima: acondicionamento térmico natural*. Porto Alegre: DCLuzzatto Editores.

Romero, M. A. (2001). *A arquitetura bioclimática do espaço público*. Brasília: Editora Universidade de Brasília.

Sedesol; ONU - Habitat. (2007). *Capítulo I: Conceptos*. Guía de Diseño del Espacio Público Seguro, Incluyente y Sustentable (pp. 29-61). Ciudad de México: Zona en recuperación.

Schiller, S. (2000). *Sustainable cities: Contribution of urban morphology*. Architecture, City, Environment: Proceedings of PLEA 2000 (pp. 353-358). Cambridge: James & James.

Secretaria de Planejamento, Gestão e Participação Cidadã. (2015). *Perfis: regiões funcionais de planejamento. Governo do Estado do Rio Grande do Sul*. Recuperado em 27 agosto, dezembro, 2015, de www.seplan.rs.gov.br/download/20150319163519perfis_todos.pdf

Shashua- Bar, L., Potchter, O., Bitan, A., Boltansky, D., & Yaakov, Y. (2010). Microclimate modelling of street tree species effects within the varied urban morphology in the Mediterranean city of Tel Aviv, Israel. *International journal of climatology*, *30*(1), 44-57.

Taha, H. (1997). Urban climates and heat islands: albedo, evapotranspiration, and anthropogenic heat. *Energy and buildings*, *25*(2), 99-103.

Thibaud, J. P. (2015). The backstage of urban ambiances: When atmospheres pervade everyday experience. *Emotion, Space and Society*, 15, 39-46.

Tsiros, I. X. (2010). Assessment and energy implications of street air temperature cooling by shade trees in Athens (Greece) under extremely hot weather conditions. *Renewable Energy*, *35*(8), 1866-1869.

Vasconcelos, L. C. S., & Zamparoni, C. A. G. P. (2011). Os efeitos da urbanização no microclima no bairro Morada da Serra, Cuiabá – MT. *Raega-O Espaço Geográfico em Análise*, *23*, 573-599.