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HEAT ISLANDS IN THE URBAN AREA OF CRATO / CEARÁ / BRAZIL

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Abstract

The present work aims to identify the islands of heat present in the urban area of Crato-CE, measuring data of temperature and humidity of the air correlated such data with the geoecological and geourban characteristics of that city. Therefore, the Thermodynamic human perception channel is adopted. For structuring the research, the fixed point methodology was adopted, analyzing the temperature of 9 am, 3 pm and 9 pm. Bibliographic surveys and cartography of the studied area were carried out. The results indicate the existence of heat islands ranging from very high to moderate intensity and the possible solutions for mitigating heat islands are indicated.

Keywords: Thermal discomfort; Human perception; Urban centers.

ILHAS DE CALOR NA ZONA URBANA DE CRATO / CEARÁ / BRASIL

Resumo

O presente trabalho tem por objetivo identificar as ilhas de calor presentes na zona urbana do Crato-CE, mensurando dados de temperatura e umidade do ar correlacionado tais dados com as características geoecológicas e geourbanas da referida cidade. Para tanto, adota-se o canal de percepção humana Termodinâmico. Para estruturação da pesquisa foi adotada a metodologia de pontos fixos, analisando a temperatura das 9h,15h e 21h. Foram feitos o levantamento bibliográfico e a cartografia da área estudada. Os resultados apontam a existência de ilhas de calor variando de muito forte a moderada intensidade e indica-se as possíveis soluções para amenização das ilhas de calor.

Palavras-chave: Desconforto térmico; Percepção humana; Centros urbanos.

ISLAS DE CALOR EN EL ÁREA URBANA DE CRATO / CEARÁ / BRASIL

Resumen

El presente trabajo tiene como objetivo identificar las islas de calor presentes en el área urbana de Crato-CE, midiendo datos de temperatura y humedad del aire correlacionados con las características geoecológicas y geourban de esa ciudad. Por lo tanto, se adopta el canal de percepción humana termodinámica. Para estructurar la investigación se adoptó la metodología de punto fijo, analizando la temperatura de las 9 am, 3 pm y 9 pm. Se realizaron levantamientos bibliográficos y cartografía del área de estudio. Los resultados indican la existencia de islas de calor que van desde intensidad muy fuerte a moderada y se indican las posibles soluciones para mitigar las islas de calor.

Palabras-clave: Malestar termal; Percepcion humana; Centros urbanos.

1. INTRODUCTION

The cities, nowadays, can be considered the epicenter of many environmental, social and economic problems. According to data provided by UN (2010), 55% of the population lives in urban areas. To 2050, is predicted that 70% of the population will live in urban spaces. In Brazil, 84,35% of people lives in cities. In this reguard, the expressive increase of the urban population in Brazil, that has been seen since de 1960s (with the urbanization process), was not accompained by an adequated infrastructure to provide the basic necessities to the population.

This agglomerate in urban areas generates a series of changes in the natural spaces. The replacement of natural areas for concretes, houses, asphalt and slums, modifies the natural equilibrium of the environmental systems. The climate is one of the elements that has been altered by the urbanization. The urban structure absorves more heat and takes time to liberate it to the space. The lack of squares, parks, green areas that serve to regulate the thermic environment, through evapotranspiration, is rare.

All of these factors and many others added create a specific microclimate in urban spaces, which Monteiro (1976) called urban climate. This microclimate has as imideate action the thermal comfort and/or discomfort. The thermal comfort "[...] expresses the satisfaction of the human body in relation to the climate condiction of the environment" (MUNIZ; CARACRISTI, 2015, p. 8). In this sense, the increase of temperature generates in people a sensation of thermal (dis)comfort, accentuating health problems, besides damage in carrying out daily activities.

The study of urban climate can help in a significant way the urban planning, since the environmental conditions are fundamental to organize the space, thinking in an urban structure more comfortable to reduce the highest thermal indixes. Muniz and Caracristi (2015) accentuate that the climate is a fundamental element for the quality of urban population.

In this regard, Brandão (2011) points out that the first evidences of preocupation regarding the quality of life in the urban environment were designed in the Industrial Revolution era, in the XVIII century, in England, France and Germany, by the studies carries out by John Evelyn (1620-1706) and Luke Howard (1883), in London, and Emilien Renou (1815-1902), in France. These researchers already realized the temperature rise problems caused by the urban/industrial grouping that was forming.

Thus, the cities are inclined to grow and, along with their growth, come the socioenvironmental problems that reach directly the urban population, since the life quality is more and more deteriorated, because the urban space misuse, without a planning that takes into consideration the well-being of the population. Many urban plannings end up prioritizing the economic aspects, without considering the social and environmental bias.

In this sense, the urban climatology "[...] stands as an oustanding knowledge area of this problematic and its study has offered important contributions to the mitigation of urban socioenvironmental problems" (ZANELLA; MOURA, 2013, p. 76). Therefore, the urban climatology can be considered as an important ally in mitigating the environmental problems, acting as a field of knowledges to be though in cities planning policies. Taking into consideration that the quality of life depends, *a priori*, on the environmental quality. And in urban areas not every person has access to an adequate infrastructure. People who have greater purchasing power end up occupying better espaces on urban soil. Consequently, they enjoy better infrastructures that favors them a better quality of life.

Therefore, we can see that the situation of most of the population facing the urban reality is critical, since it doesn't possess basic infrastructure (sanitation, monthly income, habitation and more) to live, what constitutes a state of social vulnerability.

Thinking about climate issues, in Brazil, the studies carried out by the professor Carlos Augusto de Figueiredo Monteiro stand out, which, by making public his Habilitation Thesis "*Teoria e Clima Urbano*" (1976), states the theory of Urban Climate System (U.C.S.), having as premise the General System Theory (G.T.S.), formulated by the biologist Ludwig Von Bertalanffy, in the 1960s. In general terms, the general system theory is stablished in the relation of the components that form Nature, these being in integration, where the whole is greater than the sum of the parts.

Zanella and Moura (2012) point out that Monteiro (1976) became a reference for the urban climate studies carried out in Brazil, with the help of the research program for São Paulo city, in 1970, and, after, with the publication of his thesis, where he potentialize the preocupation and studies about the climate in urban environment. For Monteiro (1976, 2011, 2015), the urban climate comprises the urbanization as a social factor, and the climate as a natural factor.

That way, Monteiro (1976) indetifies three subsystems and their respectives human perception channels: Thermodynamics (heat islands/freshness), Physico-chemical (air quality) and Hydrometeoric (impact meteors). The thermodynamic system has the heat islands as one of the products generated. The term "island", "[...] refers to the thermal espacial pattern, which will be differenciated itself as it moves away from the densily urbanized area towards the rural space" (PIMENTEL, 2017, p. 39).

So, the heat islands can be understood as a microclimate with higher temperatures in urban areas, motivated by the replacement of the natural landscape for an artificial environment. In this environment, higher temperatures can be identified both in great metropolises and in small and medium cities. The thermal core of these islands, as a general rule, is found in central areas of the cities, where can be found a largest built mass, varying in time and espace. For Garland (2010), the heat island works as a "reverse oasis", where the air and surface temperatures are higher than the ones on rural areas. Amorim and Dubreuil (2017) emphasize that the atmospheric heat islands work as hot air pockets in urban areas, as a result of the capacity of surface materials store and reflect solar energy of various ways, and of the production of athropogenetic heat.

Thus, it is questioned: are there any area in Crato city presenting highest temperatures, in relation to other places? Which factors (natural and social) condition the increase of the temperature (or decrease, in case of fresheness islands) in Crato-CE city? How the urban climate studies can facilitate the cities planning?

So, the present work aims to identify the heat islands in urban area in Crato-Ceará district, through the temperature and humidity measuring in different geoecological portions of the district.

2. MATERIAL AND METHODS

For the development of this research, was carried out, firstly, an appreciation of the bibliographic material available about the subject, consulting the works by Monteiro (1976, 2011, 2015); Zanella and Moura (2012, 2013), Pimentel (2017), Garcia (1996), Amorim and Dubreuil (2017), and others. The authors helped us to understand the urban climate and its modifications present in the cities. Also, it was made a survey on the geoenvironmental data of Crato city (Geology-Geomorphology, Climate, Soil, Hydrography and Vegetation) from works already existent, such as: Ribeiro (2004), IPECE (2010), IBGE (2010), Ceará (1997), since these factors are important to understand how is the urban climate occurs. The bibliographic survey also included the readings about the history of Crato and its urban evolution, to understand the urban context, such as the works by Oliveira and Abreu (2010), Abreu and Santana (2016).

The data analysis refers to the rainy period of the researched area (March), with an average rainfall of 258mm, having chosen the day 28th day for the discussions. For this collect, was used the methodology of fixed points with the help of thermo-hygrometers (Datalogger, model HT-50 and ITLOG90) programmed to register the data hourly. These devices stayed inside a wooden shelter, painted white, absorbing less heat, so that wouldn't occur interference in the collected data. It was selected 10 neighborhoods for the collect (Pimenta, Palmeiral, Santa Luzia, Muriti, Novo Horizonte, Novo Crato, Parque Recreio, Mirandão, Centro and Lameiro). For the choice of neighborhoods, it was taken into consideration the geoechologic and geourban characteristics, as well as the logistic and safety of the devices. The collect was done in the period of 7 am to 9 pm. This present study only analyzes three hours (9 am, 3 pm and 9 pm)

After that, it was done a cartographic survey of the area, considering the cartographic basis provided by IBGE (2015), with the use of the software Qgis to produce a localization map of the area. The data, after collected, were treated with the software Excel, through the making of graphs in the form of lines and tables. According to Oke (1978), the most important characteristic of atmospheric heat islands is its intensity. The intensity of heat islands is obtained in some situations: Intra-urban Heat Islands: differences of air temperature occur inside the territorial limits of the city (MOURA, 2008); Inter-urban Heat Islands: for each hour it was calculated the difference of each point (specifically of three points that registrated higher temperatures, the neighborhoods: Mirandão, Palmeiral and Centro) with the representative point in the countryside. In this case, it was used the data from the automatic station of INMET, which is in the neighboring district, in Barbalha. For the heat islands intensity, it was followed García's proposition (1996). This proposition states the following: 0°-2° (low intensity), 2°-4° (moderate intensity), 4°-6° (high intensity) and > 6° (very high).

3. RESULTS AND DISCUSSION

3.1. Geoenvironmental context of Crato-Ceará

The district of Crato is located in the Cariri Cearense, south of state of Ceará (Figure 1). Its geographic coordenates are 7°14'03" (lot. S) and 39°24'34" (long. W). Its 560 km away from the capital Fortaleza. It exhibits a territorial area of 1.158 km². The population is 121.462 inhabitants (IBGE, 2010) and with and estimate for (2019) 132.123 inhabitants. It is limited to the North with Caririaçu and Farias Brito, to the South with the State of Pernambuco and Barbalha city, to the East with Barbalha, Juazeiro do Norte and Caririaçu, and to the West with Nova Olinda and the State of Pernambuco. It exhibits a urbanization rate of 83,11% (IBGE, 2010; IPECE, 2010).

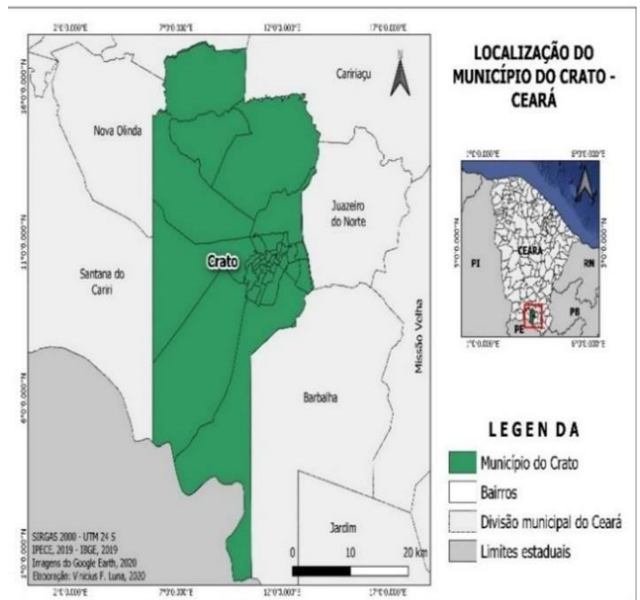

Figure 1 - Map of localization of Crato city-Ceará. Source: Authors (2020).

The district of Crato is inserted in the Sedimentary Basin of Araripe, located at the northern portion of the Borborema Province, south of the state of Ceará, and borders the states of Paraíba, Pernambuco and Piauí. Geomorphologically, the Araripe plateau, which corresponds to a landform of "tableland and structural surface, as conserved top due to inexpressive drainage, with level of approximately 800 mm, and territorial range of 6.230 km²" (RIBEIRO, 2004, p. 80). In this sense, it is possible to affirm that Crato city is priviledge from the geoenvironmental point of view, since the Araripe plateau gives the place an exceptional environment, amid proper conditions of the Semi-arid Northeast. Beyond the Araripe plateau landform, it is possible to identify, according to Ribeiro (2004), Sertaneja Depression, Massif Residual, Araride plateau hillside and Fluvial Plain.

The climate conditions, in general, follow the Semi-arid Northeast pattern, exhibiting a rainy (shorter) and dry season (longer). The climate is Warm Tropical - Aw in Köppen's classification, and Wet Tropical in the Northeast portion, influenced by the windward area of Araripe plateau. In the district, from December to January, begins the period called as rainy pre-season, in which "[...] these rains come from the atmospheric instability generated by the repercussion of cold fronts located in the South Central of Northeast, favoring the formation of convectice activity" (LIMA, 2008, p. 60). The average temperature fluctuate from 24° to 26°, and the pluviometric indexes 1.100 mm, with irregular and concentrated rains, on the trimester February, March and April.

The main rivers that stand out in the district are the Granjeiro, Batateiras, Saco Lobo and Carás rivers. Those rivers are fed by perennial springs that come from the Araripe plateau. The Batateiras and Granjeiro rivers drain the headquarters and adjacencies of the district. The Granjeiro river was retilinated in down progress, which generates flooding problems in the rainy period, what comes to invade houses built on fluvial plain areas. Not to mention the household waste and sewage added to the water volume that comes from the river, generating misfortunes (LIMA, 2008).

The prevailling soils are, according to Ribeiro (2004), associated with the sediments of the Araripe Sedimentary Basin as sandy soil with silt and clay content with variation of litography and geomorphologic location highlighting the dystrophic Red-Yellow Latosol, Litholic Neosols, Chromic Luvisols and Eutrophic Fluvic Neosols.

The relation to the vegetation, Ribeiro (2004) point out the existance of a large diversity in the phytophysiognomy, receiving influence, mainly, from the landforms and the soils, and, also, from the presence of humidity that comes from the springs, on the hillside. Thus, it is emphasized: on the top of the plateau, Carrasco vegetation and Cerradão, is also found the so called Tropical Sub-deciduous Xeromorph Forest, the Cerradão, which, according to Ribeiro (2004), is on top of dystrophic sandy soils and/or alkaline soils, at the level of 800 to 900 m. The hillside is characterized by the Tropical Sub-perennial Pluvio-Nebular Forest, also known as Wet Forest. At lower altitudes, Tropical Sub-deciduous Pluvial Forest (dry forest) and, at the pediplan, the Deciduous Thorny Forest (caatinga vegetation) (RIBEIRO, 2004; IPECE, 2010; CEARÁ, 1997).

3.2. Urban characterization of Crato

The settlement of the Cariri region occurred with the native people that was distributed throughout the humyd valley of Araripe plateau and its surroundings (ABREU; SANTANA, 2016). Crato city has its origins around 1741, when the first villages of Kariri natives appeared, which was the starting point for the Missão Miranda, founded by the Capuchin Friars from Italy.

In relation to the occupation process of Cariri, Oliveira and Abreu (2010), point out that it occurred in the same way of the Brazil occupation, with a massacre (genocide and ethnocide) of the populations that lived in the region. Still, emphasize that the colonizers devastated the Cariri between 1660 and 1680, with the persecution of the native people and the conquer of new lands, under the service of Portugal.

Crato district was elevated to the category of Vila in July 21rst, 1764, being the first Real Vila. Previously, the district belonged to the territory of Icó. About the condition of the Village, Oliveira and Abreu (2010) point out that the village was poor and small, without any espacial organization, with brick and adobe ou mud houses, covered with baçu straws and tiles. The scholars emphasize that, in the XIX century, in the 50s, the Vila Real of Crato started to be structured, with the emergence of basic services for the collective life as: market, commerce, graveyard, water suply and others.

In October 17th, 1853, the Vila Real do Crato becomes a city, under the force of the single article of Provincial Law 628, sanctioned by the president Joaquim Vilela de Castro Tavares (OLIVEIRA; ABREU, 2010).

At the moment, Crato city is encompassed by the Metropolitan Region of Cariri (RMCariri) - created by the Complementary Law nº 78, sanctioned in June 29th, 2009, that comes from the conurbation process (still in progress) of the surrounding cities (CRAto, JUazeiro do Norte and BARbalha) - CRAJUBAR, having Juazeiro do Norte emerged in front of the other cities composing the RMCariri, and being considered the metropolis of Cariri.

Abreu and Santana (2016); and Oliveira and Abreu (2010) point out that Crato continues to play an important role as medium-size city, embodying urban functions, mainly, in the teaching segment, with the foundation of the Regional University of Cariri - URCA, offering several graduation courses; the Federal Institute of Education, Cience and Tecnology (IFCE - Crato); the Federal University of Cariri (UFCA) and other private colleges.

The author, still talking about Crato city, point out that there are the Events Center, the Light Rail (LR) that connects Crato to Juazeiro do Norte, and shoe industries as Grendene. Currently, it is possible to observe, as well, the urban expansion towards Juazeiro do Norte, in the form of allotment, where property developers negociate the urban soil.

3.3. Analysis of collected field data: fixed points

It were chosen ten specific neighborhoods: Pimenta, Palmeiral, Santa Luzia, Muriti, Novo Horizonte, Novo Crato, Parque Recreio, Mirandão, Centro and Lameiro (Figure 2). These neighborhoods were listed according to some criteria, as use and occupation of the soil.

The Table 1 shows the data gathered to the analysis (March 28th, 2019), which occured during day period, from 7 am to 9 pm.

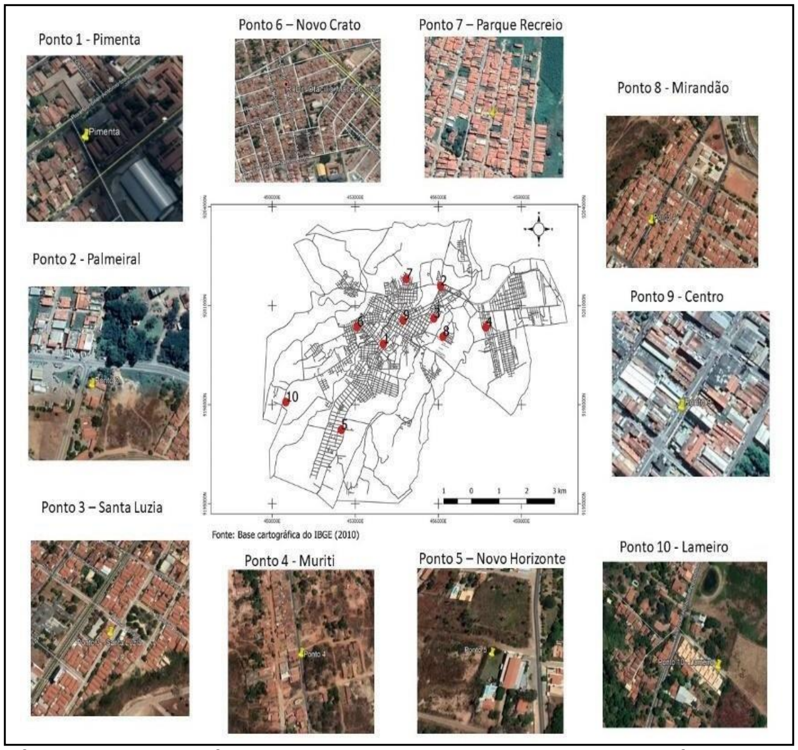

Figure 2 - Espacialization of the collect points of the research. Source: Authors (2019). Source of imagens: Google Earth, 2019.

Table 1 - Temprature and humidity data of the collect points. Organization: Authors (2019).

Te perature and Humidity Data						
Neighborhoods	Temperature (°C)			Humidity (%)		
	9h	15h	21h	9h	15h	21h
Pimenta	26,5	34,2	26,6	80,3	49,0	77,7
Palmeiral	27,4	36,2	26,9	77,9	47,1	73,9
Santa Luzia	27,8	32,3	27,2	75,1	53,0	71,9
Muriti	25,0	31,4	24,5	73,7	59,5	70,4
Novo Horizonte	25,2	28,7	24,3	80,8	53,4	80,3
Novo Crato	27,9	32,6	26,6	74,5	50,9	70,6
Parque Recreio	26,4	32,4	25,5	81,0	52,4	79,2
Mirandão	28,5	35,8	27,1	78,1	47,5	75,2
Centro	26,9	34,7	27,3	77,8	46,1	69,7
Lameiro	26,1	28,7	25,1	80,6	64,1	78,1

It was possible to point that the highest registered temperature occurred in the Palmeiral neighborhood, at 3 pm, registering a temperature of 36,2 °C. The collect point was the Zoonoses Center, where one can observe little vegetation and pavement.

In the period of 3 pm, there was less clouds, light wind and moderate circulation, and it was very sunny. Added to the lack of vegetation, these factors contributed for the high temperature, which are associated with the decreased humidity, registering 47,1%.

Although being in a rainy period, at 9 am, in Palmeiral neighborhood, was registered a 27,4 ºC temperature, diferently than the other neighborhoods, as Novo Horizonte, with 25,2 ºC, for being geographicaly closer to the hillside of Araripe plateau. The most urbanized neighborhoods such as Novo Crato, Palmeiral, Mirandão, Centro show, during 9 am, the following temperatures: 27,9, 27,4, 28,5 and 26,9 ºC, respectively. If compared to the neighborhoods closer to Araripe plateau, as Novo Horizonte and Lameiro, they showed 25,2 and 26,1 ºC, i.e., these neighborhoods show milder temperatures, due to the greater presence of vegetation and conditioning characteristics of Araripe plateau. Besides, it needs to be taken into consideration the house structures: the lots are bigger and don't have great urban concentration.

The lowest temperature at 9 am was found in Muriti neighborhood, 25 ºC, even though there was a great predominance of vehicles, for being located in an exit area from the city and a large number of residences. However, at the measuring point, still is possible to observe a greater predominance of vegetation, beyond the fact that the device was located in an open and ventilated space. It can be observed in the table that, during the period of 3 pm, the highest temperatures are registered. Having as an example the neighborhoods that shown milder temperatures, Lameiro and Novo Horizonte, registered, respectively, 28,7 and 28,7 ºC, the same temperature during night time.

The Centro neighborhood, with a larger urban agglomeration, between stores and little presence of vegetation, showed, at 3 pm, a 34,7 ºC temperature. Consequently, registered a lower humidity at 3pm, reaching 46,1%. Mirandão neighborhood also showed a higher temperature, registered as 35,8 ºC, during 3 pm. The neighborhood is expanding in the last years, showing some commerces and the presence of vegetation in some sectors is widely spaced.

At 9 pm, it was verified that Centro neighborhood shows the highest temperature: 27,3 ºC. This temperature is conditioned by the structure of many constructions, big urban equipments and little vegetation in the location of the neighborhood. The humidity increased a little in relation to the period of 3 pm, reaching 69,77%.

During the period of 9 pm, the neighborhood that registered a lowest temperatures and higher humidity was Novo Horizonte, due to its location and the geoechological features being different from the other collect points. The temperature of this neighborhood was 24,3 ºC e humidity of 80,3%. The Pimenta, Palmeiral and Novo Crato neighborhoods showed, respectively, temperatures around 26,6, 26,9 and 26,6 ºC, at 9 pm. On Lameiro neighborhood, was registered the temperature of 25,1 ºC at 9 pm, also conditioned by its geochological features.

Muriti was the neighborhood that showed the second lowest temperature at 9 pm, corresponding to 24,5 ºC, associated to the increase of humidity that reached 70,4%. The thermal width was calculated taking into consideration the Palmeiral (36,2 ºC) and Novo Horizonte (24,3 ºC) neighborhoods, which are the neighborhoods that registered the highest and lowest temperatures, respectively. The thermal width was 11,9 ºC (high width),assuming that it was the rainy period, during which the temperatures, in most of the medium-sized northeastern cities, are milder, having its highest pluviometric levels registered in the trimester of February, March and April (IPECE, 2010).

By the analysis of the data, it can be noticed that the temperatures at the three hours (9 am, 3 pm and 9 pm) had similar behaviors, in relation to the data for most northeastern cities, having as main aspect the higher intensity heat islands, identified in daytime (morning and afternoon), and in night time (also occurred, but with less intensity), the temperatures started to drop, due to the surfaces cooling. The highest peaks are in the period between 2 pm and 3 pm (period with greater presence of solar radiation).

It is also verified, considering the higher peak hour (3 pm), that, in the neighborhoods with greater vegetation cover, presence of hydric bodies, like Novo Horizonte and Lameiro, the temperatures are milder, ratifying the ideia that vegetation is a primordial element and is necessary for the climate regulation, providing thermal field amenities. Corroborating the present thought, in a study carried out in the state of Piauí, Albuquerque and Lopes (2016) point out that:

Therefore, when making the confrontation of temperatures with low and high values, that match with the neighborhoods with smaller and larger areas of vegetation, it can be observed an average difference of 2,67 °C corresponding the values 3,08, 1,76 and ,18 °C, respectively with the hours of 9 am, 3 pm and 9 pm (ALBUQUERQUE; LOPES, 2016, p. 56).

It can see that the northeastern cities follow a pattern for development of heat islands, as being in daytime, and its peak occurring between 2 pm and 3 pm, and the mainly causes of this thermal anomaly are the replacement of vegetation by an urban structure, without taking into consideration ways of minimize the effects caused by climate changes. But also it can be identified moderate and high intensities in the period of night/dawn.

3.4. Intra-urban and inter-urban Heat islands (HI)

The intra-urban heat island calculation (HI) was done taking into consideration the higher and lowest temperatures of each period of time. So: at 9 am (Mirandão and Muriti), at 15h (Palmeiral and Lameiro) and at 9 pm (Centro and Novo Horizonte). The data was analyzed according to the model proposed by Garcia *et al*. (2008), who performed a study referent to the heat islands of Madri, Spain, and reached a classification that is reference for many studies carried out in Brazil.

In the period of 9 am, the analysis between the neighborhoods of Mirandão and Muriti (28,5 and 25°C), a 3,5°C heat island was identified (classified as Moderate). At 9 am, generaly, the weather is little milder, characterizing a pleasant temperature.

Following this pattern, it is analyzed that in the period of 3 pm was found a 7,5° C (classified as Very High) heat island in the Palmeiral and Lameiro neighborhoods (36,2 and 28,7 °C). In other words, the result proves what was discussed throughout this study: the period of 3 pm was the peak of heat island in the city.

In the period of 9 pm, with the surfaces cooling, was observed in Centro and Novo Horizonte neighborhoods (27,3 and 24,3 °C, respectively), indentified a 3 °C (Moderate intensity) heat island. The inter-urban HI calculations follow the same pattern of intra-urban in the period of 9 am, 3 pm and 9 pm. The calculationwas done in the neighborhoods with higher temperature duringthe the hours: Mirandão, Palmeiral and Centro, where the temperatures were 28,5, 36,2 and 27,3 °C, respectively.

The heat islands were milder, as showed in Table 2, whereas data from INMET were gathered in the rural area, with greater presence of vegetation and hydric bodies. So, in Mirandão neighborhood was found a heat island of 1,3 °C (Low), in Palmeiral, 5 °C (High) and in Centro, 2,4 °C (Moderate).

Table 2 - Inter-urban Heat island data..Organization: Authors (2019).

Hour	Neighb orhoods	Temperature (°C)	INMET (Barbalha)	IG Calculat on	Magnitude of IC
9 am	Mirandão	28,5 °C	27,1 °C	1,3 °C	Low
3 pm	Palmeiral	36,2 °C	31,2 °C	5 °C	High
9 pm	Centro	27,3 °C	24,9 °C	2,4 °C	Moderate

3.5. Possible solutions to minimize Heat islands (HI)

Considering that one of the criteria presented by Monteiro (1976), for the structuring of Urban Climate System (U.C.S.), was the "Pragmatics", which considers the practical aplication of the studies as possible solutions to the problems encountered. In this case, the Heat Islands (HI). Therefore, it is reaffirmed the importance of urban planning to the mitigation of environmental and social problems in brazilian cities.

The planning is the key factor to reduce impacts and potencialize the positive aspects of urban climatic alterations; and the studies about urban climate have offered informations and important propositions on this aspects, even if they still are little applied in the scope of planning (ZANELLA; MOURA, 2013, p. 76).

The scholars point out the significance of planning any urban conglomerate to avoid the environmental and social impacts. At the same time, they claim that, although there is a lot of data and propositions to mitigate the heat islands, subsidized by urban climatology, these data, as a general rule, are not used. In this context, it is necessary that the public administrators at the municipal, state and federal level, create public policies and value the works that are being produced in cientific spaces, these having potencial of aplicability in spacial organization, provinding a better quality of life for the population.

Based in Gartland (2010), it is proposed some natural measures such as the afforestation of urban areas. Trees, in addition to all the scenic features, are suited to cast shadows and purify the air. The creation of open green areas, as squares and/or parks, allow the wind circulation, is an alternative. The green roofs are also and option, because they reduce the noise inside places, besides keeping the air moist and absorb the direct solar radiation (GARTLAND, 2010).

4. FINAL CONSIDERATIONS

It is concluded that Crato city, as the other brazilian cities, went throught a process of rapid and desorganized urbanization, that generated several problems. The modification in the natural landscapes alters the natural balance of the environment, as of the energy balance in the urban environments.

Like this, it is possible to infer that, in the research area, it can be found heat island of highest peak in central areas (these more urbanized). The period of 2 pm to 3 pm was proven, in this study, to the research area, as a period that showed higher temperatures (varying between high intensity and moderate intensity), and, at night, the heat islands varying in intensity, staying between Low and Moderate.

In this sense, it is suggested the application of the urban planning as an essential element in order to decrease the environmental impacts in the city, besides natural and human measures, of low cost, as arborization, construction of open green areas, to ease the processes of heat islands formation.

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