Journal of Environmental Protection, 2023, 14, 725-741
https://www.scirp.org/journal/jep
ISSN Online: 2152-2219
ISSN Print: 2152-2197

Influence of Vegetation on the Climate

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How to cite this paper: Schueler, A. and Oliveira, T.R. (2023) Influence of Vegetation on the Climate. *Journal of Environmental Protection*, **14**, 725-741.
https://doi.org/10.4236/jep.2023.149041

Received: August 11, 2023
Accepted: September 18, 2023
Published: September 21, 2023

Abstract

With the growth of the cities, the environment ended up being altered and, among others, the natural cover and native vegetation were replaced by a built environment, which contributed to deep environmental disturbances. One of them, climate change, has attracted attention in recent decades, and can no longer be ignored without greatly compromising the quality of life of human beings. From the scenario in which we are inserted, it became necessary to investigate which factors significantly influence climate change in urban centers. The Federal Rural University of Rio de Janeiro was the center of this study. From this scenario, the influence of green and wooded areas on urban thermal behavior was analyzed. In this sense, three types of soil surface exposure were studied experimentally during four periods of the year.

Keywords

Climate, Urban Forestry, Heat on Surfaces, Seropédica

1. Introduction

Climate change has been one of the biggest concerns in the field of environmental issues, with global and local relevance. The anthropogenic interferences in the natural setting are the main cause of this climatic anomaly. The unbridled growth of humanity over the years has increased the demand for food and shelter. The increase in the concentration of greenhouse gases is mainly responsible for the increase in warming on the planet. This change in temperature can transform forms of energy production, food and consequently the quality of life.

The theories of Howard (1772-1864) in his work "The climate of London" made him a pioneer in identifying changes in the temperature of urban centers. According to Achille, L. *et al.* [1] and to Oke [2] the deficient urban and territorial planning together with the model of unbridled urban development contributed to an increase in the thermal amplitude of the metropolises. In general, Brazilian cities are characterized by their rapid and disorderly growth, which contributes directly to more intense environmental problems. These changes cause thermal discomfort to the urban population, which, in order to combat the heat, increases energy expenditure with air conditioning [3].

One of the environmental problems caused by this rampant development is the phenomenon of heat islands that has as its main characteristic a high average temperature, when compared to nearby rural regions. Research in the academic sphere has given rise to studies on the phenomena and effects caused by heat islands. It was even revealed that heat islands are more intense on clear and calm days [4] [5].

The solar irradiation when it falls on the planet Earth provides five physical phenomena: reflection, transmission, scattering, absorption and emission. Solar energy transfer processes are responsible for heating the atmospheric surface. The radiation propagates in a vacuum, which in this case is solar radiation in space. When the sun's rays strike the Earth's surface, they cause two other processes: conduction and convection. Conduction is the transfer process that occurs in the molecule in the solid state while convection is the transfer process that occurs in the liquid and gaseous states.

When we refer to solar radiation, the reflection coefficient is called albedo, which is the ratio between the incident coefficient and the reflected coefficient. Thus, each surface has a distinct albedo. Kirchhoff's law states that for a given wavelength and a given absolute temperature the absorptivity of a body is equal to its emissivity, *i.e.* materials that are strong absorbers at a particular wavelength are also strong emitters at this wavelength, in the same way weak absorbers are weak emitters.

The constant changes in land cover and land use have greatly influenced the changes in the behavior of the components of the energy balance on the earth's surface, as well as all biophysical variables. Biophysical variables are important and influenced by the change in vegetation cover and serve as indicators of the climate change patterns of a region [6].

The texture of the soil is the property that undergoes the least change over time, in addition, it is fundamental for the classification of the type of soil. The different soil textures are responsible for determining the amount of water and nutrient retention. When the unitary mineral constituents of the small clods are separated, it is verified that the soil is constituted of a set of individual particles that are, under natural conditions, connected to each other, with quite varied sizes, some being large enough for observation with the naked eye, others can only be seen with the aid of pocket lenses or ordinary microscope, while the rest can be observed with the aid of electron microscope [7].

Among the properties of the soil that influence the solar reflectance, we have the humidity, the amount of organic matter, the amount of iron oxide, the relative percentage of clay, silt, sand and the characteristics of roughness of the soils

[8]. The knowledge of soil moisture is of paramount importance to indicate the water conditions of the profile. Wet soils generally have lower reflectance than drier soils. Organic matter is another factor that interferes in an inversely proportional way to solar reflectance, that is, the greater the amount of organic matter in the soil, the lower its solar reflectance.

When the organic matter content in the soil exceeds 2%, it plays an important role in determining its spectral properties. When the content is less than 2%, other soil constituents become more influential in its spectral behavior than organic matter [9] [10].

The studies to establish the amount of Carbon in the soil are based on the influx and efflux of Carbon in the soil-atmosphere system, that is, it is established by the addition of organic materials in the soil and by the removal, either by the consumption of the plants or oxidation of CO_2 in the system.

Different tools have been studied to reduce the effect of heat islands in urban centers and, among them, we have the use of vegetation in buildings such as the use of roofs and green facades, as well as the insertion of trees in road paving projects. Vegetation has an important role in the improvement and microclimatic stability due to the reduction of thermal amplitudes, direct insolation and wind speed and the increase of evapotranspiration rates [11].

In rural areas, the process of deforestation and burning are the main causes of negative environmental impacts, being responsible for changing the hydrological dynamics in the watersheds. In addition, the extirpation of trees is responsible for diminishing or extinguishing habitat of different species of animals, as well as unprotecting the soil.

In this work it was proposed to evaluate the temperature in several types of surfaces with specific plant protection at different times of the year. The measurement was made using a FLIR E-63900 thermal imager and aimed to identify anomalies in the environment.

Justification

Global concentrations of GHGs generated by human activity increased considerably between the years 1750 and 1998 [12]. The records carried out show that Greenhouse Gas (GHG) has almost doubled in its quantity. Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Sulfur Hezafluoride (SF_6), the families of perflucarbonates and hydrocarbons are considered as GHGs. GHGs come mainly from the materials responsible for generating energy, such as fossil fuels. These fuels are used in daily transportation, in industries and in the generation of electricity for the population. With social development it became essential to the presence of fuels for the generation of electricity. In large urban centers, with the increase in temperature in recent years, air conditioning has become indispensable in transportation, in homes and at work, finally in cities.

From this perspective, the reduction of GHG aims not only at the recovery of environmental quality conducive to a healthy quality of life, but also seeks to ensure conditions for socioeconomic development, which safeguards the dignity of the human person.

Thus, this study starts from the following premises for the construction of the investigation process:

- Increased greenhouse gases can increase the average temperature of the planet by up to 5˚C;
- GHG cause an opening in the ozone layer, which is a natural blocker of the sun's rays. This opening in the ozone layer favors the entry of the sun's rays into the planet's atmosphere, causing it to heat its surface;
- The surfaces of urban centers are composed, in their great majority, of products of very low permeability and dark as cement and asphalt, which contribute to the increase in the local temperature, as well as prevent the infiltration of water in the soil system causing in times of rain flooding;
- Deforestation and fires carried out in rural areas directly affect the dynamics of the hydrological cycle within the watershed, causing a lower durability and a worse quality of the water resource;
- Some techniques used in agricultural production such as ploughing, grading and burning in straws contribute to the increase in the emission of greenhouse gases;
- In rural production areas there are techniques that hinder the infiltration of water into the system, such as the lack of a living or dead cover that makes it difficult for water to remain in the system;
- The lack of vegetation in the riverbeds compromises the dynamics of the hydrological cycle and contributes to the formation of floods;
- Afforestation in urban centers favors an improvement in the quality of water dynamics and decreases the average temperature;
- Planting techniques that aim at carbon sequestration and improve soil water dynamics favor increased productivity and contribute to environmental quality on the planet.

The deficit of green areas has been large in many urban centers due to the accelerated process of development of cities. Normally, in cities located in rural areas, the implementation of urban forestry to reduce the average temperature of the environment is not observed, since the contact of the population with the peripheral green is immediate. However, as cities grow, this contact becomes more difficult, especially in those cities with radial growth.

Along with the growth of cities, the need for the presence of trees for the accommodation of people, the improvement in atmospheric quality and improvement in the microclimate was perceived. Afforestation is generally used in roads, parks and gardens. Currently, with the increase in the value of horizontal areas in urban areas we see the need to insert this vegetation in other places. For this it is necessary to have trained professionals to provide planning and design vertical gardens and green roofs. With a view to the ecological and economic aspects and the collaborative management of trees in the urban environment, the term urban forest began to be used in the sixties [13] [14].

There are in urban environments several empty spaces that can be occupied with trees and many of them allow a cluster of tree individuals that forming a plant mass can contribute, in ecological terms, much more than do isolated trees.

Given these facts, the alternative presented in this work aims to present ways to have a sustainable development in urban areas by reducing GHG emissions, the amount of energy consumed in urban centers with air conditioners, improving the dynamics of the hydrological cycle and mitigating the temperature in microclimates.

2. Literature Review

2.1. Quality of Live

It is the expression that defines the degree of satisfaction achieved by individuals or population, with regard to their needs considered fundamental. It is the sum of factors arising from the interaction between society and environment, reaching life with regard to its inherent and/or acquired biological, psychic and social needs [15].

The Human Development Index is a parameter developed by the UN to assess the quality of life of people, in this index are compared data on education level, life expectancy and GDP (Gross Domestic Product). In this way, the theme of quality of life cannot be detached from the environmental issue, because it is essential to achieve a good quality of life people need to have access to water, food and basic sanitation of quality and this is directly related to the development of environmental issues.

The inequality in the access of the Brazilian population to the universalization of the water supply network, sewage collection and solid waste management is still a great challenge for both the government and society, despite the fact that such services constitute a global parameter of quality of life [16]. For sanitation to be used as an instrument of health promotion, technological, political and managerial barriers need to be overcome in order to extend its benefits to residents of rural areas and localities of small size or low income [17].

2.2. The Right to Quality of Life and the Environment

The expression "environment" manifests itself richer in meaning (as a connection of values) than the simple word "environment". This expresses the set of elements, and the first expresses the result of the interaction of these elements. The concept of environment must be globalizing, comprehensive, of all the original and artificial Nature, as well as the related cultural assets, comprising, therefore, the soil, the water, the air, the flora, the natural beauties, the historical, artistic, touristic, landscape and archaeological heritage [18].

2.3. Benefits of Urban Forestry

Urban forests have been a topic of increasing importance in the realization of municipal planning, due to the association of the benefits provided by trees and the improvement of the quality of life of the population [19].

Among the environmental and climatic benefits we can highlight that the urban forest contributes to microclimate regulation, the improvement of environmental comfort, the reduction of surface runoff and flooding of cities, the reduction of atmospheric pollution to the detriment of carbon sequestration, the control of clarity and reflection of light and the preservation of flora and fauna. In addition, urban forestry can be used in landscape projects, such as in projects of central beds or avenues. These projects present in simple ways, usually the bed receives a row of tree species and a lining with decorative function (**Figure 1**).

Trees planted on public roads are usually inserted into sidewalks, making it difficult for aeration and water to enter the soil, essential for the development of the plant's vital functions. In general, the afforestation of urban spaces is done in environments of squares, gardens, parks, vacant lots, vacant lots, parking lots and sometimes on the banks of water bodies and backyards. Therefore, it is necessary that the implementation of this green area is done properly and that during its installation time maintenance is made, such as: irrigation, fertilization, harvesting, substitution, care with diseases and surgeries.

We also have some techniques for maintaining urban trees, pruning being the most important. It is a management carried out since ancient times whose objective is to remove branches from trees. Although it is necessary, it is important to emphasize that this management is an aggression to the trees and that this practice alters their hormonal dynamics, their structure, function, in addition to changing their defense structure against natural enemies. The correct thing is to prune so that its natural size, its aesthetics, symmetry is preserved and that its canopy remains attractive, as well as its height to the trunk.

In addition, when the means of maintenance are extinguished so that the tree remains vital it is necessary that its replacement be made. This requires technical

Figure 1. Partial replacement performed at the central site of UFRRJ Source: The authors.

reports and authorizations, and planning is important to reduce this need.

In the case of the need for suppression, the technical responsible may waive the lowering of the stump and recomposition of the sidewalk, lowering of the stump with the planting of another species or individual on the stump or that a new pit and a new planting on the sidewalk be made. The gradual replacement of trees can also be done, since the recomposition of another species would take a long time to grow and this could interfere with the landscape and the dynamics of landscaping.

Among the conflicts with the implantation of tree species in urban areas, are the management of electricity networks and lighting of poles; the roots of the trees that should avoid the lifting of the sidewalks, resist the strong winds and not invade pipes in search of moisture; the treetops advancing on the street rolling boxes, etc. Trees, on rainy days, are responsible for causing power outages. In urbanized areas, the electricity grid is usually an obstacle in urban afforestation projects. There are cases in which maintenance must be done with chemical or manual pruning, whose cost of operation is high, and causes the cost of the project to rise, consequently.

It is the responsibility of public agencies such as municipalities and private agencies responsible for the concession of public energy to make periodic maintenance such as pruning. During planning what can be done to reduce the cost is to choose a tree species of low size, suitable for the place in which it will be inserted. Energy distribution companies have made high investments in research aimed at improving the use of phytoregulators in chemical pruning. The Institute of Forest has on one side the wooded parking lot and on the other side the space for the flow of electricity. This planning reduces the expense of pruning management.

Parking lots are environments that deserve special care when planning the project. What is aimed at the implantation of the trees in the parking lots is the possibility of having the creation of a natural shade for the cars, however it is necessary to take some care. The flowerbed in the parking lot of the Institute of Biology has a Jaqueira *Artocarpus heterophyllus* as a species of tree shading. It is inadvisable to have fruit trees that fall on cars or passers-by and dirty the pavement.

3. Study Area

Soil samples were collected from specific locations on the Universidade Federal Rural do Rio de Janeiro (UFRRJ), in Seropédica-RJ (**Figure 2**). The municipality of Seropédica, was a rural and planting area and today has a characteristic of rural/urban fringe, which is shown from new uses of the soil. The municipality is located in the region known as baixada fluminense, characterized by an area of flat and low topography, closed to the mountains.

The climate of the Seropédica region, according to the classification adopted in the model of KÖPPEN, is of the Aw type, located in a climate zone is tropical

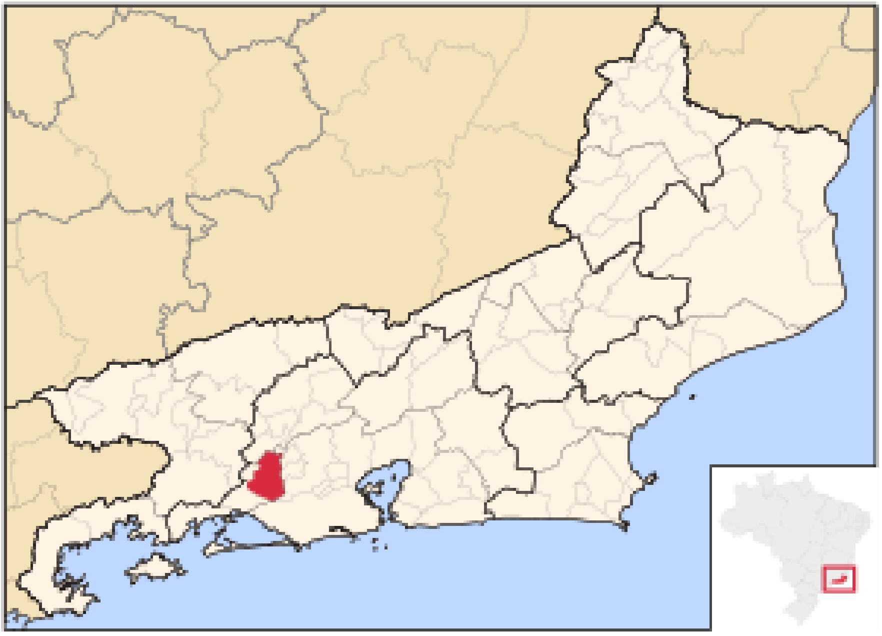

Figure 2. Map of the municipality of Seropédica. Source: Wikipédia.

subhumid with little or no water deficit and mesothermal with heat well distributed the year [20].

According to data from the meteorological station of the National Institute of Meteorology of Brazil, the average annual temperature of the region is 22.7˚C and the average precipitation of 1291.7 mm, with the dry period between the months of June and August and water surpluses between December and February.

4. Material and Methods

4.1. Equipment and Software

Using a thermal imager (Flir-E63900) solar emissions were measured on the different surfaces. In addition, the humidity of the atmosphere was measured by means of a dry bulb and wet bulb psychrometer that recorded the behavior of atmospheric temperature during the day at the three points.

The data were collected at the three points of the campus and were compared with the data obtained at the meteorological station of Ecology during the four collections that were carried out at the equinoxes of spring, autumn and at the summer and winter solstice of the southern hemisphere, with the objective of identifying in which area had the greatest influence of thermal discomfort in the different seasons of the year, in order to start the discussion of the importance of urban afforestation in thermal comfort.

The data obtained from the psychrometer were evaluated by the GRAPSI program that reported values such as wet bulb temperature, dry bulb temperature, dew point temperature, water vapor pressure, enthalpy, humidity, grams of water vapor per kilogram of air and the specific volume.

4.2. Heat on Different Surfaces

The collection sites presented heterogeneous characteristics so that they were representative of urban areas, for this purpose six types of areas were chosen: Department of Geology (DG); Institute of Biology (IB); Institute of Forest (IF); Institute of Agronomy (Lake) (IA); Theoretical Classes Pavilion (TCP); Campus Hall (Figure 3).

The soils are formed by particles of different sizes that are termed as texture, they can vary according to the literature mainly between clay (<0.002 mm), silt (0.05 - 0.002 mm) and sand (2 - 0.05 mm) and these different textures and their different arrangements in the structure influence the spectral behavior of the soil without vegetation. In addition to texture, the amount of organic matter and iron oxide cause a difference in soil color, an increase in organic matter and iron oxide will decrease reflectance. Soil moisture is also determinant in reflectance, since higher soil moisture will cause lower reflectance. This happens because moisture contributes to the absorption of energy.

The objective of the project was to collect samples and make tests in the laboratory to determine their texture and reflectance in order to compare the results obtained in the literature, in the tests in the laboratory and the images made with the thermal imager in the field.

The tests in the laboratory determined the humidity, amount of organic matter and type of texture of the sample collected, as they are the contents with the greatest effect on reflectance. Making a comparison with all the results obtained it was possible to determine which types of soils, with and without vegetation cover, caused the greatest effect on the increase in temperature. These results of the texture of the samples obtained in the laboratory were fundamental in determining the type of texture that provides greater solar reflectance in exposed soil.

Figure 3. Soil sample collection points. Source: Google earth and the authors.

The point of the Department of Geology (DG) was chosen because it is a rural area, free of any resemblance to the urban environment. The site is free of buildings, asphalt and concrete. The site of data collection has few trees which facilitates the circulation of winds, in addition to having a surface covered by undergrowth. In addition, it has a low circulation of automobiles.

The choice of the second point, the Institute of Biology (IB), is due to the fact that it is close to a built area, near an asphalted street, with little green area, with asphalted parking, in addition to being part of a group of buildings on campus formed by the (IB) and the Administrative Building of the University (P1).

The third point was chosen because it is the largest wooded area on campus with much of the ground surface covered by grass, surrounded by a parking lot and the Forest Institute building (FI).

The fourth point is located in the vicinity of a densely wooded area and lakes, near the Institute of Agronomy (IA). The circulation of vehicles is high and this area is located in a region of the campus with a lower density of buildings and free of asphalt.

Point five was chosen because it is located in one of the places with a low level of afforestation, with high car circulation, free of any vegetation and close to the Theoretical Classes Pavilion (TCP).

The sixth point was located in an area near the asphalt. It is an open area with low vegetation cover, subject to the indirect and constant incidence of the sun's rays. It has a large circulation of cars and motorcycles, as well as circulation of buses and tractors, because it is a parking point of the same. This point was chosen because it is located in one of the lowest altitude locations on campus near a mangrove area.

4.3. Heat in Different Environments

The study of temperature analysis in areas with influence of afforestation was carried out on the campus of the Universidade Federal Rural of Rio de Janeiro between the years 2018 and 2019, the study was divided into two phases: in the first phase heat was observed in different types of soil, due to the heterogeneity of buildings, their diverse flora and different uses of internal space. Soil samples were collected at six established points in order to determine the influence of soil type on solar reflectance. From this, a comparative analysis was performed between the different points chosen. Thus, measurements of the temperature of the different points were performed with the FLIR-E63900 thermal imager. Then, in the second phase, the temperature and humidity data from three points and the data from the Agricultural Ecology Meteorological Station were compared.

The results that were obtained in this research came from three field collections carried out in the periods November 31 (Spring), January 14 (Summer), and 21st May and 4th July (Winter).

To analyze and compare the data of the effects of vegetation on the urban environment, measurements of temperature and humidity of the air were made in the buildings of the women's and men's lodgings and in the sports area. These areas have characteristics of diversity of vegetation and different types of paving, however, all have as a common point the same topographic conditions.

Due to the short distance between them, we can consider that the study areas are subject to similar climatic influences.

Area 1: located in the region between the accommodation and the leisure and sports area, a pedestrian crossing place, with isolated tree units. In the vegetative aspect, it presents isolated native species of medium and large size, shrubs and grassy beds at the base of the stem (Figure 4). The point at the center is 45.9˚C.

Area 2: Unshaded area located between the accommodation and the sports and leisure area (Figure 5). The point at the center, is 64.4˚C, 18.5˚C, more than the point measured in Area 1.

Area 3: Well wooded site, with a variety of tree species, well distributed, shrubs and flowers. It has a varied, dense plant composition, with medium and large trees, impermeable paths surround its structure and presents much of permeable soil (Figure 6). The point at the center, is 34.3˚C, 15.6˚C less than the point measured in Area 1.

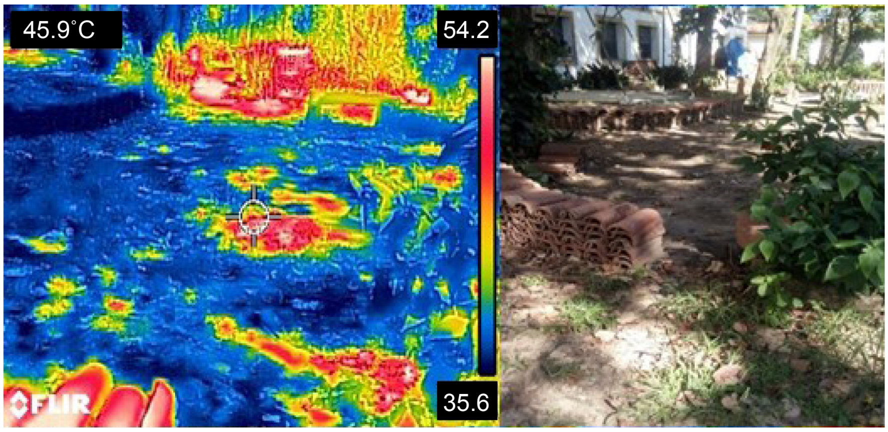

Figure 4. Partially shaded area located between the lodgings and the sports and leisure area Source: The authors.

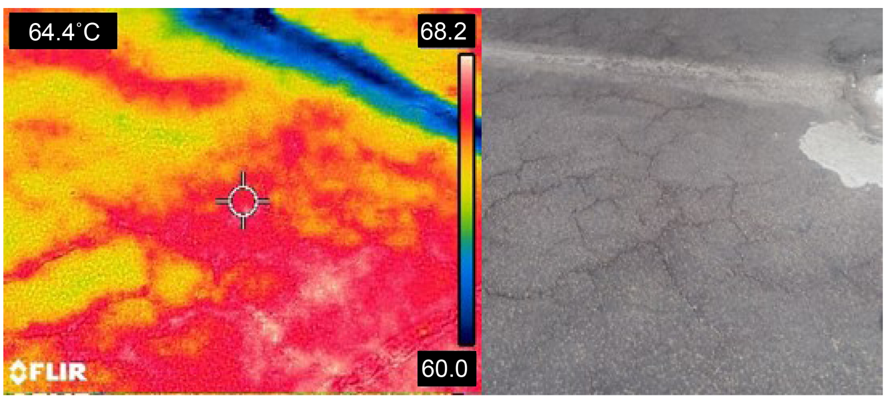

Figure 5. Area of studies located in physical education, in the areas of sports and leisure. Source: The Author.

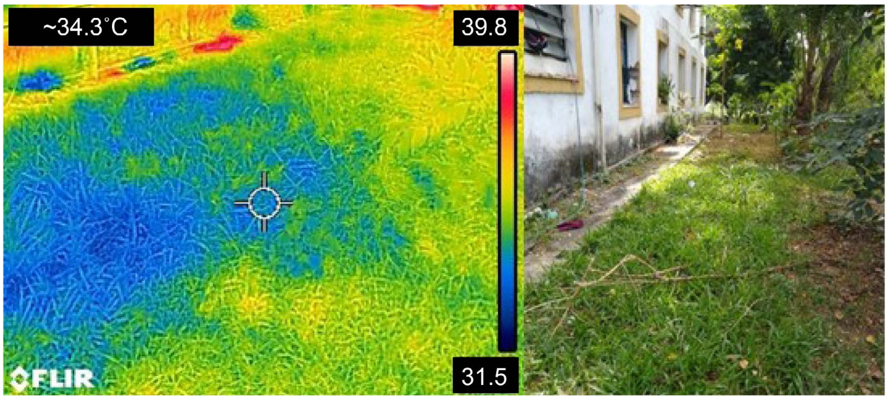

Figure 6. Fully shaded study area located between the lodgings buildings. Source: The authors.

5. Result and Discussion

Some studies point out that the texture of the soil and the distribution of the sizes of its particles are important factors for solar reflectance and the emission of surface temperatures. The soil is characterized according to the fractions of sand, silt and clay, consequently the soils can present different reflectances due to the concentration and size of the soil particles. Texture and structure are responsible for the amount of porous spaces occupied by air or water. Thus, the places that had the highest field capacity obtained a lower temperature. As examples are the points of Table 1.

Porous soil spaces can be filled by air or water. When they are filled with water, soils cause an effect of wavelength absorption and heat emission. The point presented the lowest temperature values were the points of the Institute of Agronomy (IA). The collection point of the IA is close to the lake and when compared to the other points it had the highest equivalent moisture value, 27.56%. Thus, we can conclude that the amount of soil moisture influences its absorption of wavelengths and, consequently, influences the emission of heat.

In this work the amount of organic matter from all points was less than 2% in the soil of the collection areas, so the organic matter content was not significant for the determination of temperature increase. Thus, we can conclude that in this work other soil constituents besides organic matter are important for the spectral behavior of the soil (Table 2).

In Table 2 we have: Depht (every sample were until 20 cm), Vol $(NH_4)_2SO_4$, $K_2Cr_2O_7$ - (grams), GW - Ground Weight (grams), FV - Final Volume (Final volume of the sample after the soil drying process in m^3), C (%) - Percentage of Carbon in the sample, C (g/kg) - Amount of Carbon in the sample. R1 and R2 – Two sample were collected, R1 and R2.

Particle density refers only to the solid fraction of a soil sample, without regard to porosity. Particle density is understood to be the relationship between the mass of a soil sample and the volume occupied by this solid fraction. The point that had the highest density value of the particles was the path between the Institute of Biology (IB) and the main building (P1). In general, it can be stated

Table 1. Physical characteristics of the soil samples. Source: The authors.

Samples	Particle density %	Gravimetric Humidity %	Humidity Equivalent %	Field Capacity %
TCP	2.60	1.47	11.70	15.21
FI	2.56	2.70	17.36	22.57
IA (lake)	2.63	1.73	27.56	35.83
IB	2.67	1.17	15.89	20.66
Campus Hall	2.50	1.29	15.24	19.81
DG	2.53	2.66	15.44	20.07

Table 2. Amount of carbon in the soil samples. Source: The authors.

Sample	Depth (cm)	Vol $(NH_4)_2SO_4$	$K_2Cr_2O_7$ (g)	GW (g)	FV (m^3)	C (%)	C (g/Kg)
TCP R1	2 - 20	5.00	1	0.4	24.2	−0.27	−2.72
TCP R2	2 - 20	5.00	1	0.4	24	−0.24	−2.38
Campus Hall R1	2 - 20	5.00	1	0.4	12.1	1.79	17.86
Campus Hall R2	2 - 20	5.00	1	0.4	12.6	1.70	17.01
IA R1	2 - 20	5.00	1	0.4	14.9	1.31	13.10
IA R2	2 - 20	5.00	1	0.4	15.3	1.24	12.42
IB R1	2 - 20	5.00	1	0.4	16.4	1.05	10.55
IB R2	2 - 20	5.00	1	0.4	15.6	1.19	11.91
DG R1	2 - 20	5.00	1	0.4	14.9	1.31	13.10
DG R2	2 - 20	5.00	1	0.4	15.5	1.21	12.08
FI R1	2 - 20	5.00	1	0.4	19.9	0.46	4.59
FI R2	2 - 20	5.00	1	0.4	19.7	0.49	4.93

that the higher the density of the soil, the greater its compaction and the degraded structure, the lower its total porosity and, consequently, the lower the amount of water in the porous spaces. This point presented the lowest value of gravimetric humidity, 1.17% and consequently the highest value of surface temperature with 59.10˚C. In addition, the point has a characteristic of open area and without significant vegetation, subject to direct and constant incidence of the sun's rays.

The Forest Institute (FI), although it has the highest value of gravimetric humidity, has a high temperature. The same was observed at the Campus Hall point. Both have close surface temperatures, and this is due to the similar characteristics that the two points have. The two points are located near paved roads, in addition, the two points have the same soil class, loam-clay-sandy (**Table 3**). In **Table 3** we have: ˚C: temperature, H: Humidity, Texture: Classification of the soil, FC: Field Capacity, V: If there was vegetation cover (1) or not (0), P: Porosity (dm^3), GM: Gravimetric Moisture [(Wet weight − Dry weight/Dry weight) × 100], C (%) - Percentage of Carbon in the sample.

It was observed the importance of soil areas with high moisture content and presence of vegetation cover, which cause a positive effect by reducing the surface temperature. One of the existing strategies for the retention of water in the soil is the insertion of vegetation. Research states that water retention in the soil occurs significantly in shaded environments, in addition, tree roots perform a function of sponges with water. When they have too much water, they drip to the bottom of the earth, supplying groundwater and recharging aquifers. Such factors may be related to factors such as the interception of rainwater by the tree canopy and the amount of water present on the soil surface in both environments.

The temperature and relative humidity data addressed in this study were quite significant and demonstrated that urban vegetation has a considerable influence on the parameters analyzed. Temperature and humidity are values that behave in an inversely proportional manner, that is, the higher the humidity value, the lower the temperature (**Figure 7**). Thus, we can believe that the vegetation influences the maintenance of humidity, reducing the thermal amplitudes.

Table 3. Result of soil samples. Source: The authors.

Sample	˚C	H (%)	Texture	FC (%)	V	P	GM	C (%)
TCP	49.55	11.70	Loam	15.21%	0	2.60	1.47	0.26
FI	49.50	17.36	Clay-sandy-loam	22.57%	0	2.56	2,70	1,74
AI	41.15	27.56	Sandy-loam	35.83%	1	2.63	1.73	1,40
IB	59.10	15.89	Sandy-loam	20.66%	0	2.67	1.17	1,28
Campus Hall	49.55	15.24	Clay-sandy-loam	19.81%	1	2.50	1.29	1,36
DG	45.30	15.44	Sandy-Loam	20.07%	1	2.53	2.66	0,80

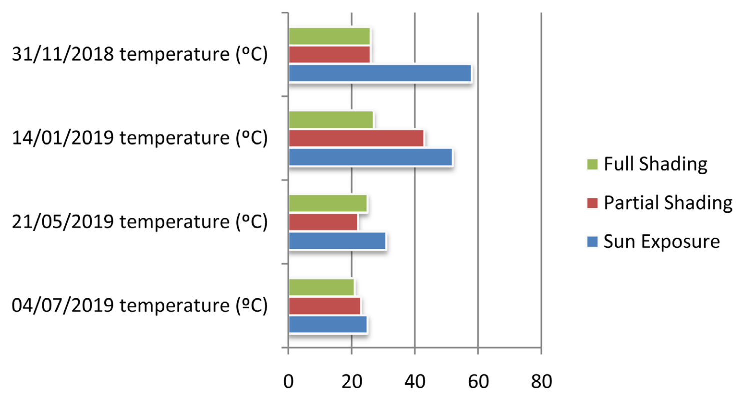

Figure 7. Graphic with the average temperature variations according to the afforestation present in each area. Sparse and isolated trees, without afforestation and well wooded. Source: The authors.

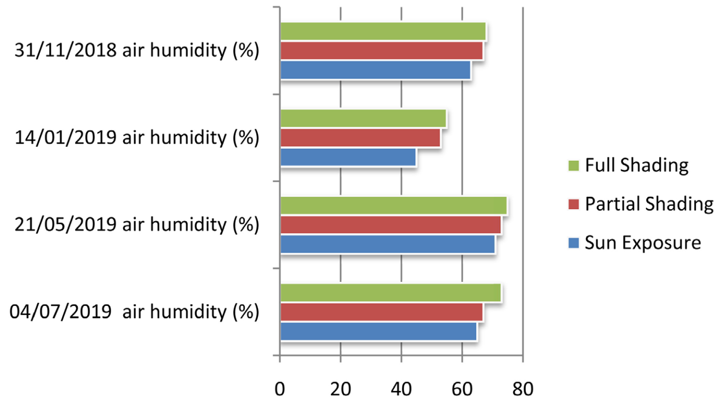

Figure 8. Graphic with the variations in the relative humidity of the air according to the afforestation present in each. Source: The authors.

The temperature measured in degrees Celsius (˚C), in area 1, which has isolated trees, shrubs and grassy beds, had its average in 32.7˚C, while in area 2, devoid of afforestation, the average temperature was 49.5˚C and in area 3, well-wooded region with medium and large trees the temperature presented an average of 29.3˚C, being a difference of 20.2˚C between the area without afforestation and the well-wooded area. For air temperature, it is noted that the area with afforestation 3, maintained a temperature always below in relation to areas 1 and 2. The values referring to the relative humidity of the air, area 1, presented an average of 65.3%, area 2, average humidity in 61.2% and in area 3, the average was 69.4% (**Figure 8**).

The data collected warns us that total shading contributes to a decrease in air temperature in urban centers. This happens because the vegetation barrier prevents the incidence of direct solar radiation and contributes by improving the humidity of the atmospheric air. According to Freitas *et al.* [21], in their studies, it shows that the points in urban centers that have the highest temperature averages and the lowest average rates of relative humidity were located in places with intense built area. It was observed in this study that the area where the relative humidity of the air was with the lowest indices is densely built and without trees, evidencing the importance of the vegetation cover with a view to increasing the thermal comfort of the population.

6. Conclusions

Soil texture contributes significantly to soil water storage and to the amount of organic matter at the soil collection points that did not have a significant influence on the surface temperature change.

Soil moisture contributes significantly to temperature which changes in the environment.

According to the research developed we could see that the presence of urban forestry provides several ecological relationships, such as: temperature reduction, noise reduction, improvement of atmospheric air quality, in addition to providing a leisure environment and improvement of the paisagism of urban centers.

It is necessary that an ideal management be made through environmental education incentives to the population, increasing and stimulating the development of environmental and ecological awareness, contributing to the improvement of the quality of life of urban areas.

Acknowledgements

The authors thank the CNPQ for the Scientific Initiation scholarship given and the Organic Matter Laboratory on the Rural Federal University of Rio de Janeiro for the trials.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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