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Vegetation Cover as a Tool for Climate Resilience in Urban Areas.

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Abstract: The invasion of asphalt and concrete with the mineralization generalized by urban zones to the detriment of the vegetation necessitates excessive heat during summer time in the Mediterranean area cities and more generally in the warm climates increase the famous effect which is the heat island aggravated by climate changes within the framework of the global reheating of the planet.

The objective of the present work is to put in evidence the effects quantified by the vegetal cover on the improvement of the thermal comfort of the urban micro-climate on a district scale within Mediterranean regional climatic context with its appropriate specificities in terms of climatic values, and this via the presentation of the results of the experimental work issued from two sets of site measurements of two different urban areas in Jijel city.

The measurement results which confirm the significant contribution of vegetal cover in the improvement of the urban microclimate should be an important element to integrate at the first stage of projection and conception of urban spaces within our cities and neighborhoods. Which will contribute to modify the micro-climate of cities and reduce energy consumption in buildings, thus minimizing the pressure exercised on its raw material in this particular case the environment.

Keywords: Urban Heat Island; Vegetation Cover; Evapotranspiration; Urban Microclimate; Mediterranean Climate; Thermal Comfort; Sustainable Urban Planning.

Introduction:

The increase in temperature at urban areas compared to rural ones, the high density of reflective surfaces on the ground and buildings surroundings, the presence of wind corridors created by tall urban structures, streets, or gaps in the urban fabric, and the low humidity caused by insufficient vegetation and grass covered areas all highlight the importance and even the urgency of introducing greenery into urban environments. This greening can be achieved through planting of urban trees as well as the conservation and enhancement of existing wooded areas in both urban and peri-urban zones. The most apparent effect of vegetation on the micro-climate is shade. Trees absorb and reflect solar radiation in such a way that individuals naturally seek shade during sunny hot days. By absorbing long-wave solar radiation, vegetation also helps reduce the gap between day and night time air temperatures. As a living element, plant cover is a measurable source of thermal comfort in Mediterranean regions (light, temperature, humidity, air quality). Vegetation also plays physiological

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and biochemical roles in daily urban comfort, while contributing to the regulation of climatic extremes (summer shading, protection against strong winds and air humidification).

With growing urbanization, on the other hand, species diversity tends to decrease. Urbanization levels often favor certain generalist or exotic species (a phenomenon particularly visible in the fauna of urban parks). The loss of native species may be masked by the presence of less sensitive exotic species. This gradient can be interpreted as a gradient of habitat loss, with isolation effects occurring when the urban matrix no longer allows for species dispersal. Recent scientific studies have emphasized the importance of reconnecting urban parks to create multifunctional green networks that address both environmental and social challenges (Clergeau, 2013).

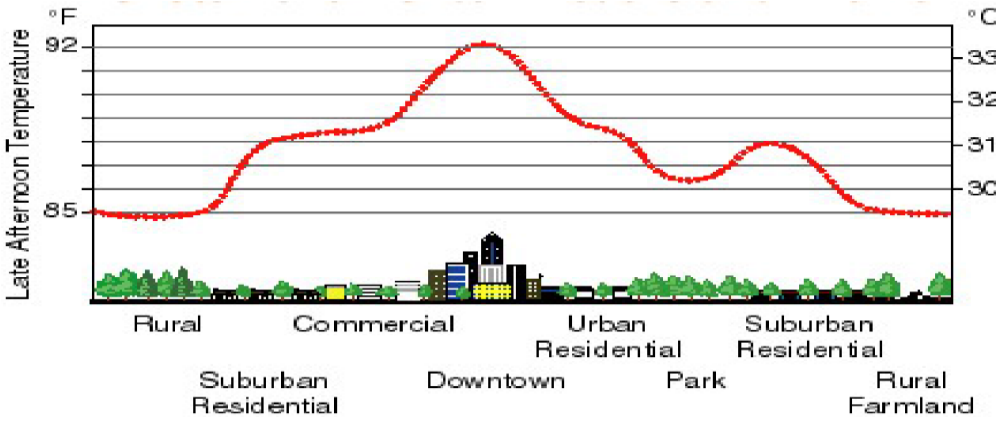
Recent systematic reviews have examined UHI mitigation strategies across different climate zones. Studies show that SUHI intensity is higher in tropical and subtropical climates, while Mediterranean cities demonstrate moderate cooling intensity. Research on coastal cities, such as Dalian (China), indicates that proximity to water bodies influences both UHI magnitude and vegetation cooling effectiveness. However, most studies focus on large metropolitan areas in Europe and North America, with limited empirical data from North African Mediterranean cities. This research gap justifies the need for localized measurements in cities like Jijel, where
tourism and coastal dynamics create unique urban planning challenges.

The objective of this work is to highlight the effects of urban green networks on improving the thermal conditions of urban microclimates and their influence on their parameters. This allows us to consider mitigating the urban heat island effect through economic means that promote optimal climatic conditions, leading to a better perception and reappropriation of urban spaces.

1. Urban Vegetation and the Improvement of Urban Microclimates

1.1 Vegetation and the Urban Heat Island1

Figure 1 : Diagram of the urban heat island profile.



Source: Cool Roof systems, Inc., 2004.

Climatic parameters are altered in the vicinity of buildings, where an urban microclimate is observed. In summer, the microclimate has more restrictive characteristics than meteorological data due to the overheating effect caused by sunlight on the ground and facades.

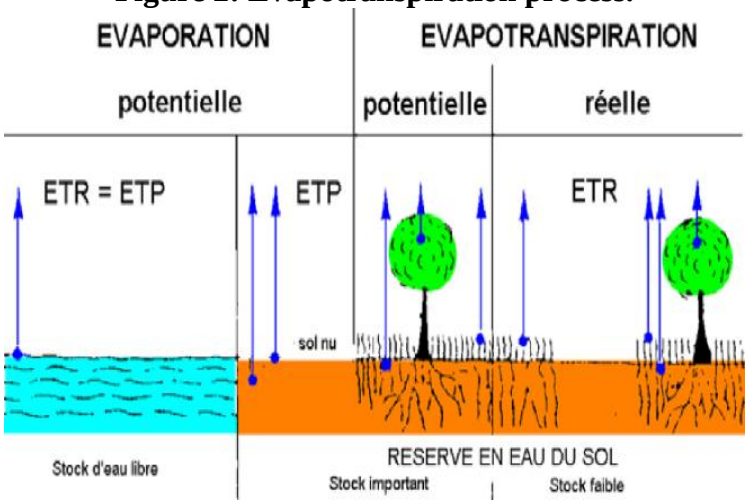
Vegetation influences three main parameters: solar radiation, wind, and air humidity. The cooling effect that occurs within parks extends to the surrounding urban areas, thereby contributing to the improvement of their microclimates (Oke, 1989) (Figure 1). The humidity originating from parks does not negatively affect the thermal comfort of users (Vu Thanh Ca et al., 2000).

1.2 Evapotranspiration and Thermography

Trees planted in mineral surfaces have warmer foliage compared to those planted on lawns surfaces. High water loss from leaves is caused by elevated leaf temperature values (*Tf*) on top of asphalt, which leads to prolonged stomatal closure.

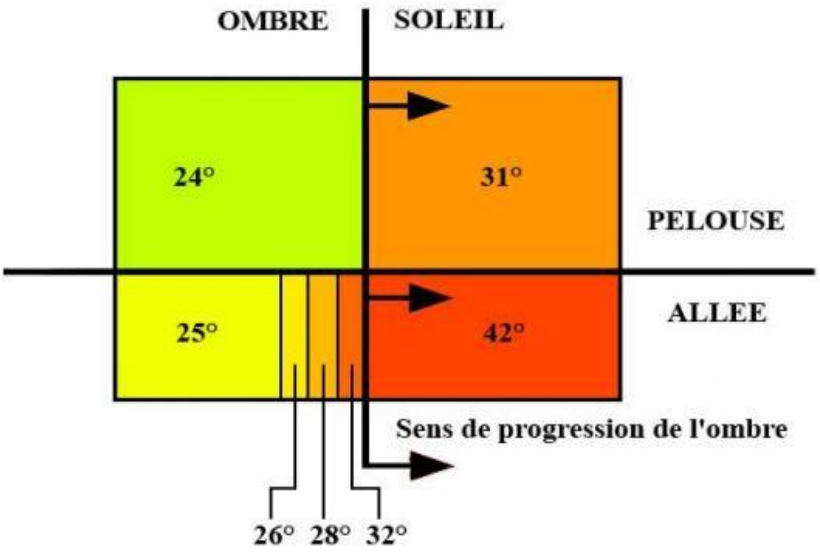
Through the process of evapotranspiration, vegetation modifies both temperature and humidity levels at the foliage scale. At the same time, the change in humidity originating from trees and parks does not negatively impact the thermal comfort of users, even in hot and humid climates (Vu T.C. et al., 2000). Also wind speed is significantly reduced in areas covered by vegetation; however, the cooling effect of vegetation is canceled out once wind speed exceeds 5 m/s (Bruse et al., 1999).

Figure 2: Evapotranspiration process.



Source: Jacques Beauchamp.

Figure 3: Diagrams comparing the thermal effects of grass in shaded and sunny conditions.



Source: Izard et al., 1998.

In shaded conditions the difference is smaller; however, due to its thermal inertia the mineral surface cools more slowly and its temperature remains higher than that of grass. Thermography is a method of metric pyrometry in which the measurement of an object's temperature is linked to its emissive properties. This technique enables the analysis and visualization of the surface temperatures of objects.

2. Research Methodology

Two urban areas were selected for their representativeness within the city of Jijel and for the climatic effects they generate at the neighborhood scale.

The two sites were selected to represent real-world urban conditions in Jijel, allowing for practical application of findings in urban planning. The use of a reference meteorological station (El Achouat-Taher) provides a baseline that enables isolation of vegetation effects from other environmental variables,

including coastal proximity.

The first site located in the *Plage* neighborhood, is composed of both collective and individual housing with a relatively dense vegetation cover, the second site, located in the *Cité Ayouf* neighborhood, consists of collective housing without any vegetation cover.

On-site temperature and humidity measurements were recorded using a portable thermo-hygrometer type Testo 625, which provides instant digital readings with a measurement range of -200 to +1370 °C and an accuracy of ±0.5%.

Air velocity was measured using an anemometer.

2.1 Study Area Presentation:

The city of Jijel, a major seaside tourism destination located in northeastern Algeria, was chosen as the study site. It is situated at latitude 36.47° N and longitude 5.46° E, and is characterized by a Mediterranean climate: hot and humid in summer, cold and rainy in winter. *Figure 4* shows the geographical location of the city of Jijel.

Figure 4 : Geographical Situation of the City of Jijel.



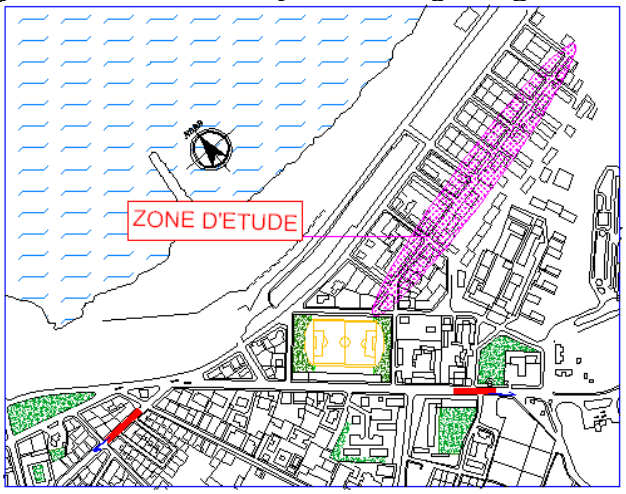
Source: Authors' elaboration based on geographical data

2.2 Experimental Work through On-Site Measurement Campaigns:

The *Plage* neighborhood:

This neighborhood is characterized by a vegetation cover composed mainly of rows of *Platanus* (plane trees) with deciduous leaves. This type of vegetation allows light to filter through in winter, provides protection from heat in summer, and is well adapted to pruning as well as to the living conditions of urban environments (*Figures 5 and 6*).

Figure 5 : Location map of the *Plage* neighborhood



Source: Adapted from Google Maps/OpenStreetMap

Figure 6 : Dense vegetation cover

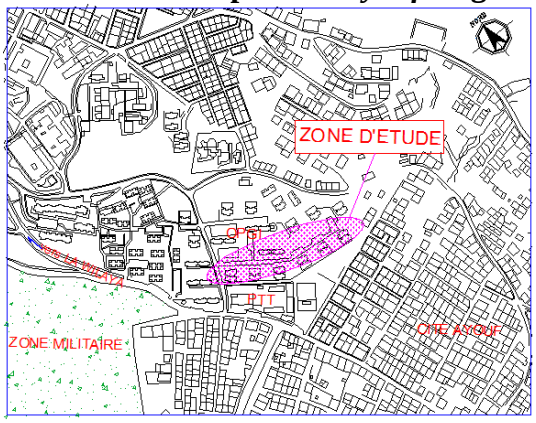


Source: Adapted from Google Maps/OpenStreetMap

-The *Ayouf* neighborhood:

The *Ayouf* urban residential area does not have any significant vegetation cover capable of improving the environment microclimate. Instead, it is mainly composed of mineral surfaces, buildings fully exposed to solar radiation, asphalt, and concrete sidewalks (*Figures 7 and 8*).

Figure 7 : Location map of the *Ayouf* neighborhood



Source: Adapted from Google Maps/OpenStreetMap

Figure 8 : Mineral surface without vegetation



Source: Authors' photographs, 2024

2.3 Measurement Protocol:

Two climate measurement campaigns were conducted at the two sites in the city of Jijel: the first on May 10, 2024, the second on July 4, 2024. The measurement points for each site were selected in order to capture the expected urban climatic effects.

On-site measurements were carried out in five time sequences (07:45–10:00, 10:00–12:15, 12:00–14:15, 14:00–16:15, and 16:00–18:15).

Recordings were taken every hour in order to obtain the values of all measured climatic parameters (air temperature °C, relative humidity %, and wind speed m/s) within the selected urban spaces, with reference values taken from the *El Achouat–Taher* meteorological station. This methodology allows for a comparison between a site with relatively dense vegetation cover (*Plage site*) and a site that is almost entirely mineralized and uncovered (*Ayouf site*), according to the following protocol:

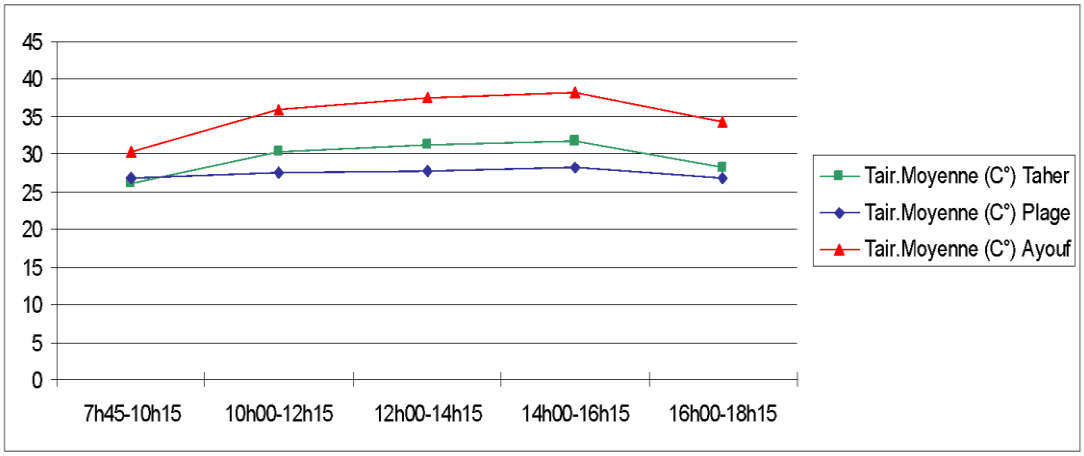
1. Data collection has been carried out with reference to the El Achouat–Taher meteorological station.
2. Measurements were taken in each hour at the same point within the study neighborhood.
3. Instruments were paused to change measurement points and sites.
4. Measurements were then taken to the next point.
5. Data were averaged, ensuring temporal synchronization between on-site measurements and those from the reference meteorological station.

3. Interpretation and Discussion of Results:

3.1 Temperature Differences Between the Two Sites:

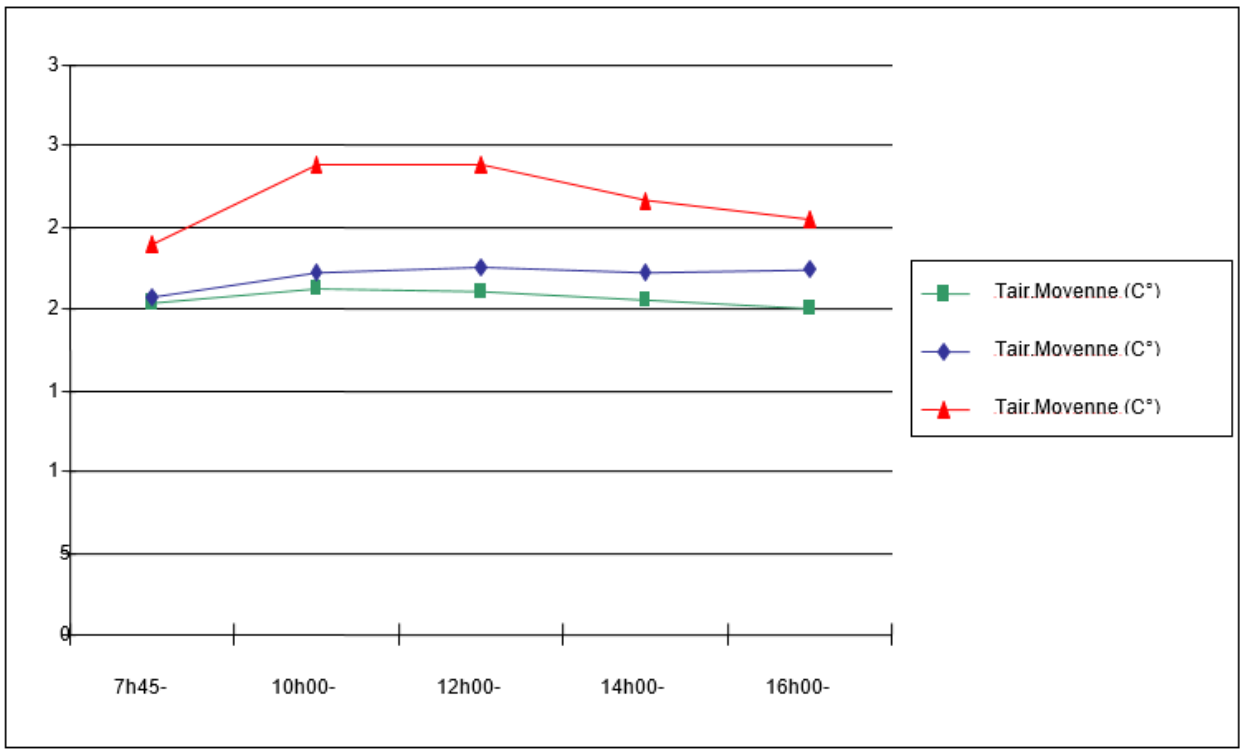
A significant gap in temperature values was observed from the first time sequence between the *El Achouat–Taher* meteorological station and the Ayouf study site (*Figure 9*). This “urban effect” was absent at the *Plage* site ($\Delta Ta.max = 3.6$ °C, 07:45–10:00). The difference is explained by the permanent shading effect of trees in the *Plage* district on mineral surfaces. At the *Ayouf* site this temperature gap increased throughout the day and remained noticeable in the late afternoon due to the overheating of mineral surfaces.

Figure 9 : Comparison of air temperature values between the two study sites and the reference meteorological station during the first measurement campaign.



Source: Authors' analysis

Figure 10 : Comparison of air temperature values between the two study sites and the reference meteorological station during the second measurement campaign.



Source: Authors' field measurements, July 4, 2024

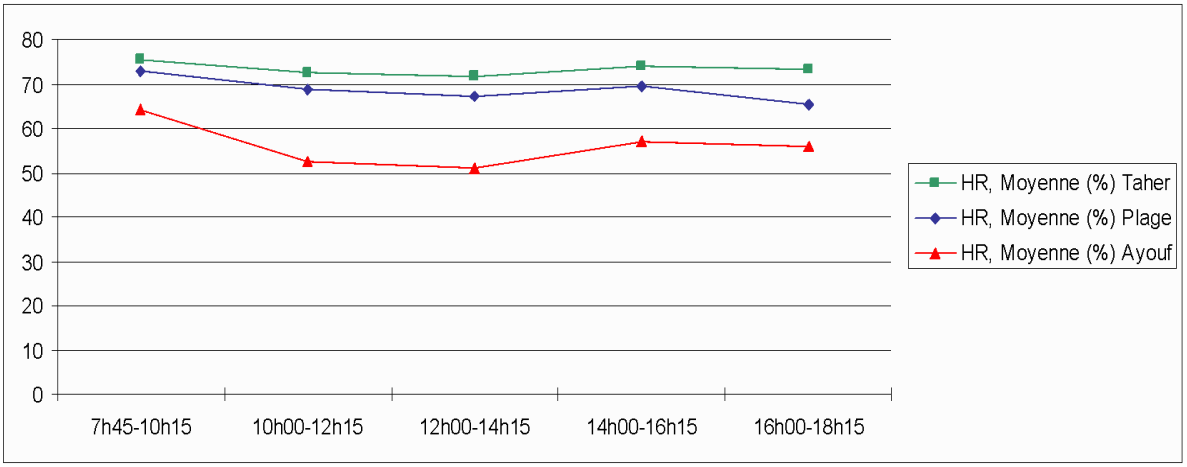
The temperatures recorded in the *Ayouf* district placed the microclimatic conditions in an extremely uncomfortable hot zone (*Figure 10*), while the same parameters recorded in the *Plage* district fell within an acceptable hot zone. Vegetation provides permanent shading of the ground and building facades, thereby improving the habitability of outdoor spaces and protecting the interiors of buildings (Izard, 1997).

3.2 Relative Humidity Differences:

The analysis of relative humidity values shows a significant difference from the early hours of the day (*Figures 11 and 12*). The humidity levels observed in the *Plage* neighborhood enable air cooling, which supports the evapotranspiration process of vegetation. This creates a favorable

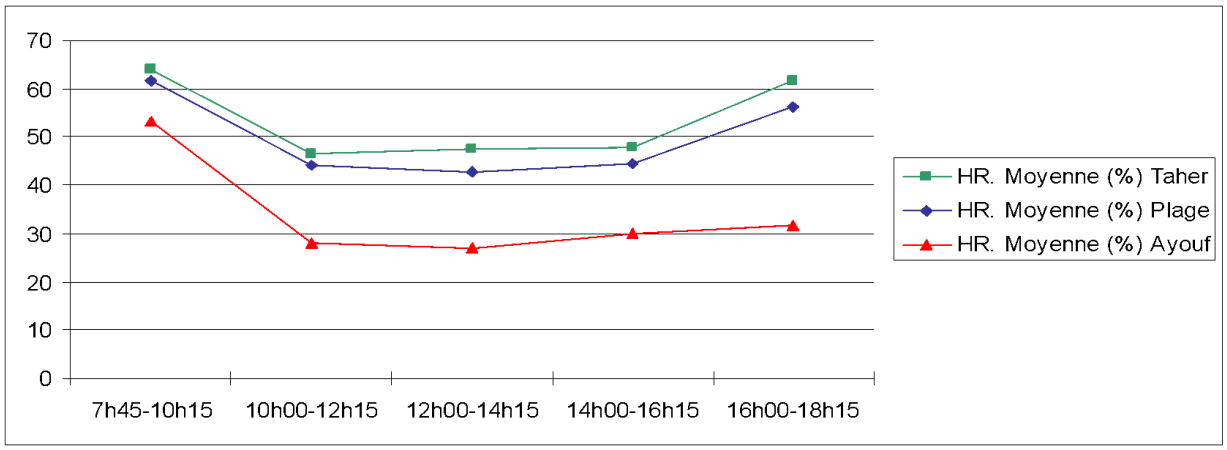
microclimate for energy exchange between vegetation and the atmosphere. Higher relative humidity also reduces water consumption by trees which allows certain species to survive with smaller amounts of rainfall.

Figure 11 : Comparison of relative humidity values between the two study sites and the reference meteorological station during the first measurement campaign.



Source: Authors' analysis

Figure 12 : Comparison of relative humidity values between the two study sites and the reference meteorological station during the second measurement campaign.



Source: Authors' analysis

It can therefore be concluded that relative humidity values in the Jijel eco-region—as a representative of a Mediterranean city—constitute a favorable factor for the development of urban vegetation cover and consequently for the expected improvement of urban microclimates.

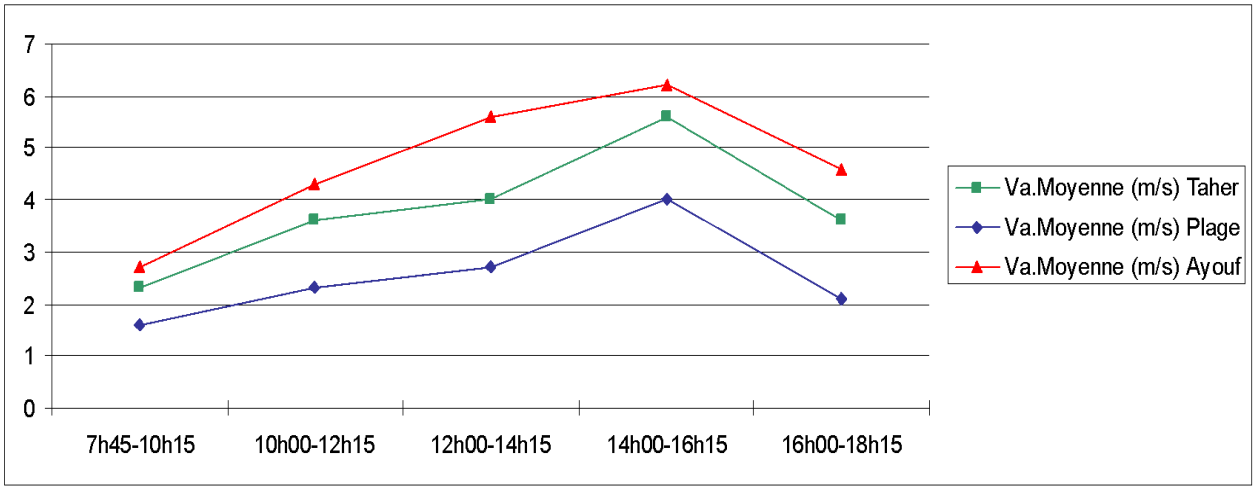
A low relative humidity rate combined with weak rainfall levels would require the implementation of a relatively dense vegetation cover (e.g., alignment trees grouped as clusters on lawns) with regular irrigation, allowing it to create its own microclimate favorable to its development and to its moderating role against urban overheating. This is not the case in the Jijel region, where climatic conditions are naturally favorable.

3.3 Variation in Air Velocity:

The maximum air velocity values were recorded in the Ayouf neighborhood (Va.max= 6.2 m/s). Differences were observed between the *Plage* site and the weather station on the one hand and between the Ayouf site and the Plage site on the other one (Figures 13 and 14). The location of the study areas, their configuration and the density of vegetation cover explain these differences. The morphological and topographical characteristics of the study sites and especially the predominant role

of vegetation cover in reducing air velocity in the Plage neighborhood provide a clear explanation for these differences.

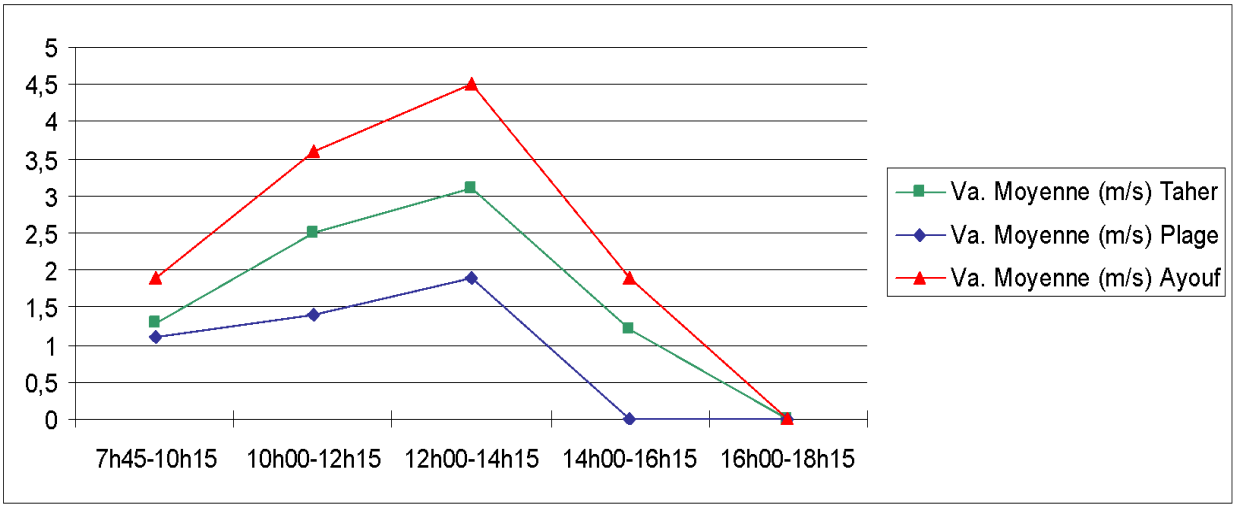
Figure 13 : Comparison of wind speed values between the two study sites and the reference meteorological station during the first measurement campaign.



Source: Authors' analysis

The analysis of wind speed values on *10/05/2024* (*Figure 14*) clearly shows a reduction in wind speed in the *Plage* neighborhood due to the slowing effect of vegetation cover. Conversely, the increase in wind speed in the *Ayouf* site is the consequence of mineralized and rough surfaces (Wagner et al., 1993).

Figure 14 : Comparison of wind speed values between the two study sites and the reference meteorological station during the second measurement campaign.



Source: Authors' analysis

The low relative humidity values observed in the *Ayouf* district are due to the strong mineralization of this urban area (the “mineral effect”), combined with the low vegetation rate. The analysis of the graph, which shows a rapid increase in wind speed values from the early hours of the day, also explains these observations. That is, higher wind speeds accelerate foliage transpiration which leads to lower leaf surface temperatures (Dimoudi & Nikolopoulou, 2000).

Table 1: Comparative Analysis of Vegetation Cover Impact on Urban Microclimate

Parameter	Plage Site (Vegetated)	Ayouf Site (Mineralized)	Observed Impact
Vegetation Type	Dense rows of *Platanus* trees	None (Asphalt & Concrete)	Permanent shading vs. direct solar exposure
Maximum Air Temperature	~28.0°C (moderate peaks)	>38.0°C (extreme peaks)	Significant overheating in mineralized zone (Fig. 10)
Relative Humidity	45–70% (moderate)	<30–55% (dry conditions)	Vegetation retains moisture; mineral surfaces dry out air (Figs. 11-12)
Maximum Wind Speed	~4.0 m/s	6.2 m/s	Vegetation acts as windbreak; mineral surfaces accelerate wind flow (Fig. 14)
Thermal Comfort Zone	Acceptable Hot Zone	Extremely Uncomfortable Hot Zone	Vegetation significantly improves habitability

Source: Authors' field measurements

Note: Data summarized from field measurements conducted on May 10 and July 4, 2024, at five time intervals daily (07:45–18:15) at two urban neighborhoods in Jijel, Algeria.

Conclusion:

The results of these measurements and observed effects confirm the significant contribution of vegetation cover in mitigating the urban heat island effect and the positive impact of green roofs and terraces on the indoor thermal comfort of buildings. These features enhance the energy efficiency of constructions and should be integrated from the earliest stages of urban planning and design. By their inclusion they contribute to the optimization of thermal performance and a notable reduction in building energy consumption, therefore easing pressure on natural resources—namely, the environment.

Our study established the presence of a *city effect* characterized by the warming of urban zones compared to surrounding rural areas. This urban heat island phenomenon can be beneficial during winter, given heating needs. However, during summer—particularly in a region like Jijel with increasing tourist accommodation demands—it becomes critical for indoor thermal comfort and energy demand for cooling, thereby exacerbating greenhouse gas emissions.

The preservation and integration of vegetated spaces into urban environments and hospitality infrastructures contribute to improving microclimatic conditions. Green spaces help mitigate the urban heat island effect linked to mass urban tourism, also reduce energy consumption and promote sustainable management of the urban areas.

Additional approaches may include the creation of alternative destinations on the periphery, as well as the adoption of smart solutions for managing and directing visitor flows—for example, through time-slot reservations via municipal websites. Such strategies help balance growth with overtourism.

The results obtained confirm the hypotheses of our research and highlight that it is time to act in alignment with nature—providing visitors with enriching experiences while preserving natural resources and improving the quality of life of the host community.

Future research should focus on developing practical mechanisms for implementing vegetation cover in urban planning, including species selection criteria, irrigation systems, and maintenance protocols suitable for Mediterranean coastal cities.

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