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Research Article

GEOGRAPHICAL ANALYSIS OF THE FACTORS AFFECTING THERMAL COMFORT IN AL-MASHKHAB DISTRICT

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ABSTRACT

The climate is one of the most important environmental factors that affect human comfort and health, as the human body responds to climatic elements involuntarily due to their effect on the heat exchange process between the human body and the thermal environment in which it lives. Several thermal comfort indicators were applied to determine the limits of thermal comfort in the study area (Ghom indicator and wind cooling indicator k), which depended on the most stable climate elements in the study area (temperature, relative humidity, and wind). As a result, the climatic seasons of the year were determined based on the cold winter months (December, January, and February). The spring season is represented by the months of (March and April), which are moderate, while the summer season represents The hot months (May, June, July, August, and September). The months (October and November) represent the fall season.

The study concluded after comparing the results of the monthly distribution of climate indicators with the classification limits of human thermal comfort that the state of thermal extremism did not appear, represented by the great stress that threatens health during the months of the year, while the state of severe thermal discomfort appeared clearly, especially during the day of the summer months (severe hot discomfort) and the nights of the winter months (severe cold discomfort), so these two seasons are the

least suitable for practicing most types of activities in open places, while the most suitable times for practicing various activities were represented by the spring and fall seasons, as the degree of influence of climate elements on the human feeling of comfort varied during the months of the year as in Tables (3, 5), and the study recommends the necessity of linking various human activities and events to human thermal comfort and linking vacations to the months of thermal discomfort.

Keywords

Thermal comfort, wind cooling index k, Qarina Thom, Al-Mashkhab district.

Introduction

Since ancient times, man has realized the impact of climate on various aspects of his life, so he tried, by all means, to adapt and acclimatize to the prevailing climatic conditions in the different seasons of the year on the one hand and harness the available technologies to overcome them on the other hand, as man feels uncomfortable if the air temperature rises or falls below 37 degrees Celsius, which is the normal human body temperature, meaning that there is a certain range of temperatures within which man feels comfortable and satisfied with the thermal environment, and outside this range he either feels hot or cold, and this feeling of dissatisfaction with the thermal environment may turn into a feeling of thermal stress, which has negative effects on the human body and activity. To reach a state of thermal equilibrium with the surrounding environment, physiological responses occur within the body, which may lead to stress for some elements of the thermoregulatory system, in addition to the impact of other climate elements directly related to human comfort, including solar radiation and relative humidity as well as wind speed. Any difference or change in these elements will be followed by its impact on human comfort, activity, and health, which requires taking the necessary precautions in a manner compatible with all aspects of activities to reach a level of comfort.

The degree of feeling of thermal comfort varies from one person to another depending on several factors, some of which are related to the person himself (subjective factors) and some of which

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are related to climatic conditions (environmental factors). Therefore, it is not practical to set a standard or guide for each individual to measure the degree of thermal comfort or discomfort. Therefore, studies have focused on searching for the relationship and impact of climate on humans and working to find methods and tools that measure the relationship between climatic conditions and the vital and physiological activities of the human body quantitatively and express the human feeling of comfort or discomfort with an acceptable degree of accuracy through the reactions of large numbers of people towards the factors affecting comfort. As a result, many standards have emerged, some of which depend on measuring one climatic element or two or more. As for the prevailing climatic conditions in the study area, the researcher saw that the best that can be applied from the indicators is (Ghom's indicator) in light of the elements of temperature and relative humidity and the combined effect between them and (the wind cooling index k) in light of the elements of temperature and wind speed, and they are the most reliable for this study due to the accuracy of the results, as the Ghom's indicator was designed to be used in areas The climate of the study area is hot and dry most of the year. The wind cooling index k was designed to be used in cold and hot areas to show the effect of wind on a person's feeling of thermal comfort.

Research Problem

The following scientific questions represent the research problem

1. Is there a relationship between the elements (environmental and subjective) and human thermal comfort in the study area?

2. Is there climatic extremism in the study area, and can any of the months of the year be determined as suitable for human thermal comfort?

Research Hypothesis:

The study hypothesis provides hypothetical solutions to the study problem, and the research hypothesis is represented by the following:

1- The elements (environmental "climatic" and subjective "physiological") affect human thermal comfort.

2- Applying thermal comfort criteria will help us determine whether the months are comfortable.

Research Objectives:

1. Giving a clear picture of the nature of the bioclimate and the limits of thermal comfort in Al-Mashkhab District by applying Garina Thom and the wind cooling index k.

2. Determining the climatic regions during the year.

3. Knowing which climatic elements most impact human physical and psychological health.

4. Evaluating the need for energy use for cooling in summer and heating in winter.

5. Determining the most appropriate times (complete thermal comfort) to practice all activities.

METHODOLOGY

An analytical approach was adopted when writing the research by analyzing the information, data, and tables related to the topic. The research comprises two chapters: an introduction, conclusions, and recommendations. The first chapter dealt with the relationship between the bioclimate and the extent of thermal comfort for humans. In contrast, the second chapter dealt with quantitative representation by applying thermal comfort standards in the study area. The research also included an appendix to the monthly rates of the most important climate elements affecting thermal comfort during the climate period (2013-2023) based on the Al-Mashkhab climate station, which was installed on (11/12/2007) and is located on longitude (44.2386) and latitude (33.3217) (Agricultural Meteorology Center, data published on the website, (https: //www.agromet.gov.iq) as it is the closest to the study area.

Boundaries of the study area:

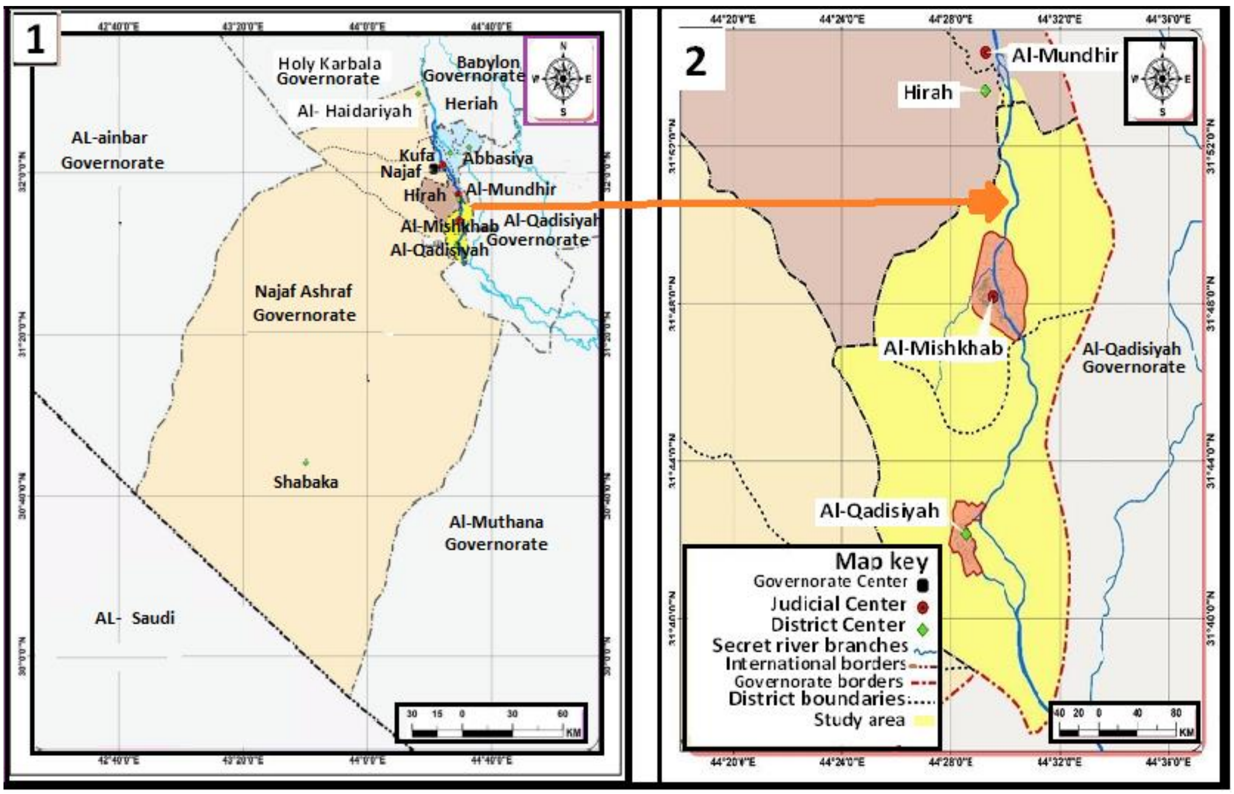
1. Spatial dimension: Al-Mashkhab district is located within the administrative borders of Najaf Governorate in the southeastern part, as Al-Mashkhab district was a district affiliated with Al-Mundhirah district, but After the amendment in 2015 and the creation of Al-Mashkhab District, the latter included the district center and Al-Qadisiyah sub-district after they were two sub-districts affiliated with Al-Munathera District (Hamed and Alawi, 2019: 395). Al-Mashkhab District is (30 km) south of the city of Najaf and is located between latitudes (″42′36°31 - ″48′54°31) north and longitudes (″20′24°44 - ″28′32°44) east (Map - 1-). It is bordered to the north by Al-Munathera District and Al-Hirah sub-district, to the east by Al-Qadisiyah Governorate, to the southwest and west by Al-Shabaka sub-district, and the northwest by Najaf District (Al-Janabi, 2021: 5-6). The area of the study area is (409 km2). It consists of two administrative units, which are the Al-Mashkhab District Center, with an area of (132 km2) and Al-Qadisiyah District, with an area of (277 km2) and the area of Al-Mashkhab District, which represents about

(1.4%) of the total area of Najaf Governorate, which is (28,824 km2) as in (Table -1-).

The largest part of the Al-Mashkhab district is located within the alluvial plain with an area of (332 km2), and the remaining area is located within the western plateau with an area of (77 km2) (Khalifa and Al-Zamili, 2023: 478).

2- The time dimension: This dimension is represented by a climate cycle extending (2013-2023).

Map (1) Location of Al-Mashkhab district in Najaf Governorate



Source: The researcher based on:

1. Geographic Information Systems Technology, Arc GIS Desktop 10.7 program.

2. Republic of Iraq, Ministry of Construction, Housing, Municipalities and Public Works, Directorate of Urban Planning, Najaf Governorate, Najaf Administrative Map, 2010, unpublished data, 2024.

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Table (1) Area of administrative units in Al-Mashkhab District

Area Km2	Administrative Unit
132	Al-Mashkhab District Center
277	Al-Qadisiyah District
409	Total

Source: Najaf Governorate Statistics Directorate, estimates of the population of Najaf Governorate according to administrative units for 2020.

The first section: The relationship between the bioclimate and the extent of human thermal comfort:

The bioclimate studies the impact of climatic elements on all living organisms in a specific geographical area (Musa, 2002: 9). Therefore, there is a direct relationship between the bioclimate and thermal comfort. The climate, with its elements (solar radiation, temperature, wind, rain, relative humidity, evaporation), is one of the most important elements of the natural environment that affects humans and their various activities in all world regions (Abdul Hussein, 2016: 229). The impact of climate characteristics also varies according to the nature of the element and the extent of human response, and the continuity of life on the surface of the Earth depends on the ability of humans to adapt to the conditions of the natural environment like other living organisms (Al-Yasiri: 2013: 2).

Thermal comfort is a complex concept requiring the convergence and intersection of large environmental, physiological, and psychological variables. Not all people respond to thermal conditions similarly due to physical differences. The feeling of thermal comfort varies between people. Also, it varies for the same person from time to time, which makes it difficult to establish a specific concept of thermal comfort. First: The concept of thermal comfort: Thermal comfort is defined as a mental state of the nervous system,

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which evaluates the human feeling of comfort in his surrounding thermal environment, and it is of two types: physiological comfort and psychological comfort, as it expresses the state of thermal balance between the human body and his thermal environment, as medical studies have proven that the human brain seeks to stabilize the body temperature at the limits of (36.8 ° C) and in the event of its decrease, the body resorts to increasing the temperature by shivering, and when it rises, it seeks to reduce it by sweating (American Society of Heating, Refrigerating and Air, 2009, Chapter 16-11)) Watson defined it as a state of mind that expresses satisfaction and acceptance of the surrounding thermal environment, which means that a person does not prefer, under these circumstances, an environment that is colder or warmer than the one in which he is present (Watson, Donald & Kenneth Labs, 1983, : 26), and Auf 1994 defines it as "a group consisting of temperatures, radiation temperatures, relative humidity, and air speed during which he feels The majority of people feel completely comfortable, satisfied, and free from feeling hot or cold. The effect of comfort on a person is determined based on the previous elements, as well as depending on the type of activity that the person is doing and the thermal insulation factor of the clothes that he is wearing (Obaidat, 2007: 22). It is also known as the condition that occurs when the thermoregulatory mechanisms in the human body are at their lowest activity, as the human body is physiologically comfortable within the thermal environment, i.e. it does not feel hot or cold ((Hedge, 2007). When a person's interest shifts from his work to his interest in changing the surrounding thermal conditions, a state of distress called thermal discomfort begins. It was defined by the American Society of Heating and Air Conditioning Engineers (ASHRAE) in ASHRAE Standard 55 as the psychological state that a person reaches when he feels satisfied with the thermal environment (Wahb et al., 2021: 198). It can be defined as the state of thermal equilibrium between the body and the surrounding environment while maintaining the body's normal temperature (37 °C), i.e., the body's heat resulting from the chemical reactions taking place inside it (metabolism) is equal to the amount of heat lost outside it through conduction, convection, and radiation methods

Second: Thermal comfort theories:

To reach standards or indications that can be formulated in several scales and relied upon to determine human thermal comfort, many

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researchers have developed numerous indicators through which the climate can be quantitatively described, and the amount of climatic thermal comfort for humans can be determined. These indicators proceed according to two theories:

1- Physiological thermal comfort:

These are indicators that depend in their measurement on variables and quantitative data about the person himself and are based in their calculation on experiments conducted on people in laboratories equipped and prepared for these experiments and with environments and thermal conditions that can be precisely controlled and through them the physical reactions that result in reaction to different thermal conditions can be calculated, and biometeorological engineers prepare these indicators.

2- Physioclimatic thermal comfort:

These are the indicators that depend in their calculation on the nature of the climatic conditions in the environment or the place surrounding the human being, especially those elements that affect the physiological comfort of the human being, such as air temperature, relative humidity, wind, etc., such as the "wind cooling index k" and "Thom" for measuring climatic thermal comfort. These indicators aim to study the relationship between climate and the human being - the physiological climate - and to describe people's different feelings in terms of their feeling of comfort or distress under climatic conditions and to determine the best places and times in which the human being performs his vital functions in the best way, in light of applying the results of these indicators and distributing them within a geographical framework (Ibrahim, 2011: 4).

Third: Conditions for the thermal comfort of the human being:

Three basic conditions govern the thermal comfort of the human body, which are:

1- Thermal balance of the human body (heat production in the body = heat loss from the body).

2- The skin temperature (depending on the physical activity that the human being is practicing at that moment) should be within certain limits not exceeding (34°C) It should not be less than (30.5°C), noting that the comfortable limits are for the temperature to be (33-34°C).

3- The percentage of sweating from the human body should not exceed a certain percentage, depending on the physical activity the person practices (Al-Bashir, 2009: 71).

Fourth: Thermal balance between the human body and its environment:

It is represented by physiological or natural comfort. It expresses the state of thermal balance between the human body and the surrounding environment, which depends on several factors, including (personal and environmental). Thus, the body maintains a constant temperature of (37°C); any change in this temperature may be dangerous and threaten its health and life, so it releases an excess of it to the external environment. As a result, there is a continuous heat exchange between the body and its environment, and this exchange takes two forms:

1 - Acquired heat: It is in two forms:

A- Self-produced thermal energy:

The human body, through metabolic activity based on burning food, generates the energy the body needs, part of which is converted into heat. So that the resulting heat does not harm the body, it is disbursed to the outside according to a specific flow (Ammar, 2019: 37).

Metabolism is the amount of heat the body produces in one hour from a unit area (m^2). The metabolic rate is classified into three categories: Fernandez, p. Lavigne, 2009: 93:

- Basal metabolic rate: The result of energy consumption to perform internal vital activities, with an average of 75 watts.
- Resting metabolic rate: The heat produced in a resting state, reaching 105 watts.
- Active metabolic rate: This is related to the type of physical and even intellectual activity.

B- Thermal energy acquired from the surrounding environment:

It is done in three ways: conduction, convection, and radiation, where a person is exposed to two sources of radiation: solar radiation (direct, scattered, or reflected) and terrestrial radiation, and the acquisition occurs from the environment surrounding the human body (Jabbar, 2012: 26).

2 - Heat lost:

When the body's thermal balance is disturbed as a result of exposure to unusual conditions, physiological processes play the role of a regulator to restore thermal balance to its normal state through the following methods:

A- Heat lost through sweating:

The body's heat loss through sweating is considered one of the most important processes in maintaining a balanced temperature. The evaporation of sweat from the surface of the human skin is the effective factor, not the sweating process itself. When sweat evaporates, it needs thermal energy, part of which it obtains from the body. Thus, its temperature decreases. This physiological process is only activated in the

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case of a thermal contrast between the body and the surrounding environment.

B- Heat lost through breathing:

It is a process that takes place through the lungs during the inhalation process, as the air is saturated with water. It is at the same temperature as the body's internal tissues, and with exhalation, the water molecules evaporate. By the end of the process, the internal tissues of the lung have lost part of their heat (Ben Chikha, Maryam Madawi, 2019: 61).

C- Heat lost by radiation:

It is a heat exchange between the surface of the human skin and the surrounding surfaces facing it using long-wave rays. Here, heat is transferred from the higher to the lower degree. This phenomenon depends on the temperature of the skin surface and the temperature of the surfaces, in addition to the emission coefficient of the human body (Sabr, 2004: 18-19).

H- Heat lost by convection:

The amount of heat lost from the human body by convection is affected by the temperature difference between the body and the surrounding air and its speed. The body gains heat from the air if the temperature difference favors the air, while it loses heat towards the air in the case of a low air temperature compared to the skin. As for the speed of the air, it affects this process, considering that high speeds ensure greater friction between the skin and the air in contact with it (Ministry of Construction and Housing and Ministry of Planning, 2013, "Chapter Four 4/1").

K- Heat lost by conduction:

It occurs through the outer surface of the human body when it comes into direct contact with the surrounding objects, as heat flow occurs from the body when its temperature is greater than the temperature of the surface it is in contact with. Reverse flow occurs if the surface temperature exceeds the body temperature (Abdul Rahim, 1994: 61. (

Fifth: Factors affecting the thermal comfort of the residents of the study area:

Many studies have been interested in identifying the factors affecting thermal comfort. Despite the differences between all these studies and their fields of interest, they have agreed that maintaining the thermal balance between the human body and its thermal environment is related to two categories of factors (environmental factors and subjective factors), which are as follows:

1 - Environmental factors:

They are physical factors represented by the climatic characteristics surrounding the human

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being, as climatic elements, whether individually or collectively, affect the comfort of the population and then their mental and muscular performance, and due to their great impact, these elements were included individually or collectively in all indicators used to measure comfort conditions Thermal and we will discuss the most important climatic elements used for analysis and clarification purposes, which are as follows:

A- Solar radiation:

Solar radiation is defined as the intensity of sunlight falling on a unit area in a unit of time, and is expressed in W/m2, and the intensity of radiation varies according to the geographical location and seasons of the year, and the intensity of radiation also varies throughout the day depending on the brightness of the sun, solar radiation is considered the most influential variable in temperature, and the sun is not the only source of radiation, as any body that stores a certain amount of heat radiates to bodies that are less hot than it and that are separated from it by a transparent medium such as air and glass, and some researchers estimate the effect of radiation temperature to be twice the effect of dry temperature, and radiation heat consists of direct rays of the sun and rays reflected from surfaces, which affect the thermal balance of the human body as the human body absorbs infrared rays directly or through its clothes, thus raising its internal temperature, in addition to the fact that the human body gains energy when the temperature of the surrounding environment exceeds (33°) and the most comfortable conditions are when the average radiation temperature is higher by (2°) than the air temperature Liebard, A., Herde, A., 2004: 29)).

Due to the astronomical location of the study area, it receives large amounts of sunlight in the summer due to the apparent movement of the sun and its approach to the Tropic of Cancer. Thus, the angle of solar radiation approaches the vertical position, thus achieving the highest amount of solar radiation in July (720.8 Calories/cm2) and then gradually decreasing to reach its lowest in the winter during December, estimated at (284.4 Calories/cm2) due to the apparent movement of the sun and its approach to the Tropic of Capricorn. Thus, the northern part of the globe receives less sunlight.

A- Temperature:

Temperature is the most important, as all other climatic elements are directly or indirectly linked. As a result of its difference from one place to another, the distribution of atmospheric pressure and thus the system of air movement and blowing differs (Al-Rukabi, 2010: 27). It is also one of the most important factors affecting human thermal comfort, as it directly affects the thermal balance between the body and its surroundings. The ambient air temperature affects the rate of heat loss from within the human body. If the air temperature is higher than the skin temperature, the speed of heat transfer from the skin to the surrounding areas decreases. In this case, the body gains additional heat, which leads to sweat secretion and evaporation, which results in a feeling of coldness. However, if the ambient air temperature is lower than the skin temperature, the rate of heat loss increases (Al-Yasiri, 2013: 2). Therefore, air temperature is used as a criterion to evaluate thermal performance for several indicators that aim to determine the level of thermal comfort, for the sake of simplicity, considering that air temperature is the most influential. The actual temperature of the Earth's surface varies greatly due to radiation, conduction, and convection processes. As a result, the maximum temperature during the day does not occur at noon exactly but a little later, usually between two and three o'clock in the afternoon. The minimum temperature does not occur at midnight, but a little before sunrise the next day, around six o'clock. This situation continues in a cycle that occurs daily, and this cycle is called the daily temperature variation. Both the maximum and minimum temperatures are of great importance, as they indicate the state of thermal equilibrium between the amount of heat gained and lost, as well as reflect the nature of the rise and fall of temperature and affect the general temperature rates. The monthly temperature rates of the study area are characterized by a gradual increase starting from March and continue to rise to reach their maximum in July (34.2 °C). The temperature decreases significantly after September, reaching its lowest in January (10.3 °C). The minimum monthly temperature rates also vary; the lowest is in January (4.5 °C), while it peaked in July (26.4 °C). The maximum monthly rates also varied during the year and ranged between (42.0 °C in August and 16.3 °C in January). The reason for the increase in temperatures during the summer months of the year is due to the angle of incidence of the sun's rays, which is vertical or near-vertical, the increase in actual brightness rates, the length of the day, and the dominance of hot continental tropical air masses (cT). Their decrease in the winter months is due to the inclination of the sun's rays, the decrease in actual brightness rates,

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the shortness of the day, and the dominance of cold polar air masses (cP). B- Relative humidity: Humidity has a significant impact on the thermal sensation (Hadi, 2018: 6), as the evaporation of water from the body (breathing, sweat) represents a basic element in temperature regulation techniques. It is known that the evaporation process consumes a large amount of thermal energy, which results in cooling the body, and the evaporation process is affected by the atmosphere's moisture content. Thermal comfort can be achieved when the relative humidity is between 20 and 80%. The lower the humidity is, the more the person feels severe dryness in the skin and constant thirst with dry lips and nose, which is inconsistent with thermal comfort regardless of the temperature. When the humidity increases above 80%, the feeling of shortness of breath increases, as water cannot evaporate inside the lungs, in addition to the water not evaporating from the skin's surface. The discomfort resulting from the increase in temperature increases with the increase in relative humidity, as sweat can't evaporate from the skin's surface. Thus, its effect in reducing body temperature stops, in addition to the discomfort resulting from the feeling of wetness (Bakr and Rasool, 2023: 442). Humidity is directly affected by temperature, as relative humidity is inversely proportional to temperature (Al-Samarrai, 2007: 119). Therefore, its rates vary significantly from one month to another during the year. Through the climatic data in (Appendix 1), we note that the relative humidity rates in the study area decrease during the summer months to reach their lowest in June (30.4%), coinciding with the rise in temperature rates, while the monthly rates of relative humidity increase in the winter to reach their highest in January (60.9%) due to the decrease in temperatures, in addition to the region being exposed to cold, humid air masses. This explains the increase in the values of maximum and minimum relative humidity during the winter months of the year and their decrease during the summer months, as the values of minimum relative humidity reach their lowest levels during the summer months at a rate of (15.4%, 9.4%, 11.0%, 13.1%, 15.9)% for each of (May, June, July, August, September) respectively. These rates are dangerous to human health, especially for those suffering from respiratory diseases. Then, it rises gradually during the fall months and continues during the winter to reach its peak in December (38.1%), then declines during the spring months. The monthly rates of maximum relative humidity also varied during

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the year and ranged between (51.4% in June and 85.2% in January).

A- Airspeed:

Airspeed affects the heat exchange between the human body and its surroundings, as it cools the body by losing heat through convection and increasing the evaporation of sweat. The higher the airspeed, the higher the level of feeling comfortable to the highest limit because it increases the heat flow and thus the feeling of satisfaction in hot weather. However, wind speed is a problem in cold conditions and the case of very hot winds. If the air temperature is higher than the skin temperature, this increases the rate of skin gaining heat through convection over the rate of heat loss due to evaporation. Therefore, it is noted that airspeed is undesirable in very hot areas. However, if the air temperature is lower than the skin temperature, increasing the air speed means the body loses more heat, which increases the feeling of coldness (Al-Wakeel and Siraj, 1989: 230). The airspeed should range between 3-4 m/s. If it is less than that, it causes discomfort as the person is surrounded by the vapors rising from his body, and the feeling of heat increases. It is also difficult to bear higher speeds due to the strength of the winds and the raising of obstacles, even if the temperature is suitable. As for the study area, the monthly rates of wind speed vary slightly, as they reach their lowest during October (1.0 m/s), while the highest wind speed was recorded during June and July (2.1, 2.0 m/s), respectively. It is clear from this that the rates of wind speed in the study area fall within the average ranges, so they have an effective role in the feeling of thermal comfort. 2 - Subjective (physiological) factors:

The feeling of thermal comfort is related to the thermal balance between the body and its environment, which prompts us to review the subjective (physiological) factors of the body that intervene in the level of thermal environment acceptance, which are as follows:

A- Activity:

The activity exerted is one of the basic factors in a person's feeling of thermal comfort, as there is a direct relationship between muscular and mental effort and the heat generated inside the body, especially with high-effort activity, as the heat generated may reach (10) times what is produced by metabolic activity in a state of rest. Several studies have confirmed that the energy consumed by the body to perform an activity has a return of no more than (20%), while the remaining (80%) is released in the form of heat (Ammar, 2019: 41).

B- Clothing:

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Clothing represents a barrier to heat transfer and reduces the feeling of thermal disparity because it creates a transitional microclimate between the skin and the clothes. The difference in their colors affects the amount of radiation they reflect or absorb, so when covering the body with clothes, the latter The role of the thermal insulator between the skin and the surrounding environment, which completely changes the rate of heat loss or gain from the environment, and clothing is an important means of thermal regulation and achieving comfort, taking off and putting on a coat greatly changes the feeling of comfort, and transfers a person from a simple state of discomfort to a state of complete comfort (Saloum, 2018: 80).

T- Metabolism:

Metabolism is defined as chemical reactions that occur inside the body and convert matter from one form to another and produce energy. Hence, an increase in metabolism leads to increased energy inside the body.

The level of metabolism inside the human body is affected by environmental factors such as temperature, as its level is inversely related to temperature, so it increases in cold weather and decreases in hot weather. The metabolism level is also affected by biological factors such as gender, age, and health status, in addition to the various activities of the body (Al-Zeer, 2021: 157).

C- Health status:

It means the safety of the organs and the body's freedom from psychological diseases, and the safety of the organs means the safety of the senses and internal organs in the body and its complete freedom from diseases.

C- Gender:

The physiological and vital characteristics of men differ from women, as the percentage of fat in women's bodies is higher than men's, and men have a greater muscle mass than women, in addition to the fact that men's metabolic rate is higher than women's. All these differences affect the process of thermal balance between the body and the environment for both sexes, causing differences in their responses to different temperatures and, thus, differences in the feeling of comfort or distress (Hasiba, Amal, 2018: 19).

H- Age:

The physiological state of a person differs according to age, as older people adapt more slowly than young people. The older a person is, the more in need of warmth. Studies have shown that those over (40) years old prefer one actual temperature higher than those under (40) years old. This is due to the effect of the main defenses in the body with age (shivering, blood vessel constriction) and the difference in levels of physical fitness and the level of physical activity that affects their temperature regulation (Al-Damini and Halbouni, 2009: 406).

The second section: Quantitative representation through the application of thermal comfort standards in the study area: The optimal thermal comfort for the human body is not determined by climatic conditions alone but is linked to other factors represented by the subjective factors of the human being himself (Ibrahim, 2004: 173). Since the thermal comfort of the human being results from a complex effect of many variables (Khalil, 2019: 126), it was necessary to deduce many clues and rely on some applications and equations to measure comfort and discomfort. Measuring human comfort through some climatic standards is one of the indicators that can be used to measure the relationship between the human being and the environment in which he lives (Oliver, 2005: 227). The goal is to create conditions where human beings can work efficiently or sleep comfortably and where the devices responsible for regulating body temperature are at their lowest level. Many indicators of biological classification can be used to determine the extent of human interaction with climatic conditions, thus determining his feeling of comfort. Still, each of these indicators has a special method and style of processing. For this research, the "wind cooling index" k and the "Thom index" were applied as indicators of thermal comfort in light of more than one climatic element as follows:

First: Thom index to measure thermal comfort (discomfort coefficient (:

Thom developed a relationship in the United States of America in 1959 AD to determine human comfort under certain climatic conditions based on temperature and relative humidity. Thom used this standard, called the Temperature Humidity Index" and is symbolized by (THI). It is the most accurate indicator in determining the bioclimatic regions based on temperature and relative humidity and is based on the following equation:

$THI = T - 0.55(1 - H)(T - 14.5)$

Since:

THI = Thom index.

T = air temperature (°F).

= H Relative humidity (%).

The clitoris is used to determine the effect of heat and humidity on the human body, not the effect of cold, so its use and the limits of its classification value are for hot regions and hot periods of the year when the temperature exceeds (14.5)

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degrees Celsius (58 degrees Fahrenheit) (Table 2).

(Table 2) Classification limits of the clitoris to determine human comfort

Comfort type	Values THI
severe discomfort (cold)	10less than
Medium discomfort (cold)	10 and less 15
Relative comfort (tends to be cool(	15and under 18
Totally comfort	18and under 21
Relative comfort (tends to be hot(	21and less than 24
Moderate discomfort (hot(	24and less than 27
severe discomfort (hot(	27and less than 29
High stress and health hazard	29 and more

Source: (Mukhtar, 2017: 256)

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To reach the truth of the impact of climate elements on human comfort, activity, and health in the study area, what is known as Thom's temperature and humidity coefficient was used to determine human comfort through the famous equation (THI). As a result of the relationship between air temperature and relative humidity, the researcher extracted general comfort values from the monthly averages of air temperature in degrees Celsius and relative humidity. Daytime comfort was also extracted from the monthly averages of maximum and minimum relative humidity rates, and nighttime comfort was extracted from the monthly averages of minimum and maximum relative humidity rates. Through this, the limits of thermal comfort were calculated in the study area, as a person feels comfortable conditions and an ideal atmosphere when the values of the temperature and humidity index range between (18 - 21), as the feeling of discomfort begins outside these two limits, as shown in Table (3) and Figure (1 (:

Table (3) Results of applying the Thom index (general, day, night) for the Mishkhab climate station for the period (2013-2023)

Night		During The Day		General		
Significance	Result Application	Significance	Result Application	Significance	Result Application	
Moderate discomfort (cold)	5.2	Relative comfort (tends to be cool)	15.6	Moderate discomfort cold)(	11.1	January

Moderate discomfort (cold)	6.8	Relative comfort (tends to be cool)	17.4	Moderate discomfort cold)(	13	February
Moderate discomfort (cold)	10.5	Complete comfort	20.1	Relative comfort (tends to be cool)	16.6	March
Moderate discomfort (cold)	13.7	Relative comfort (hot)	22.7	Complete comfort	19.6	April
Complete comfort	18.8	Moderate discomfort (hot)	26.8	Moderate discomfort (hot)	24.4	May
Relative comfort (hot)	21.9	severe discomfort (hot)	27.8	Moderate discomfort (hot)	26.9	June
Relative comfort (hot)	23.5	severe discomfort (hot)	28.4	Moderate discomfort (hot)	26.7	July

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Realtef Comfort (Hot)	23.9	severe discomfort (hot)	28.6	Moderate discomfort (hot)	26.7	August
Relative comfort (hot)	21	severe discomfort (hot)	27.6	Moderate discomfort (hot)	25	September
Relative comfort (tends to be cool)	17.3	Moderate discomfort (hot)	24.6	Complete comfort	20.8	June
Moderate discomfort (cold)	11.3	Complete comfort	20.3	Relative comfort (tends to be cool)	16.3	July
severe discomfort (cold)	6.4	Relative comfort (tends to be cool)	17.1	Moderate discomfort (cold)	12.3	December

Source: The table is the work of the researcher based on Table (2) and Appendix (1). Figure (1) Values of the application of Garnet Garnet (general, day, night)

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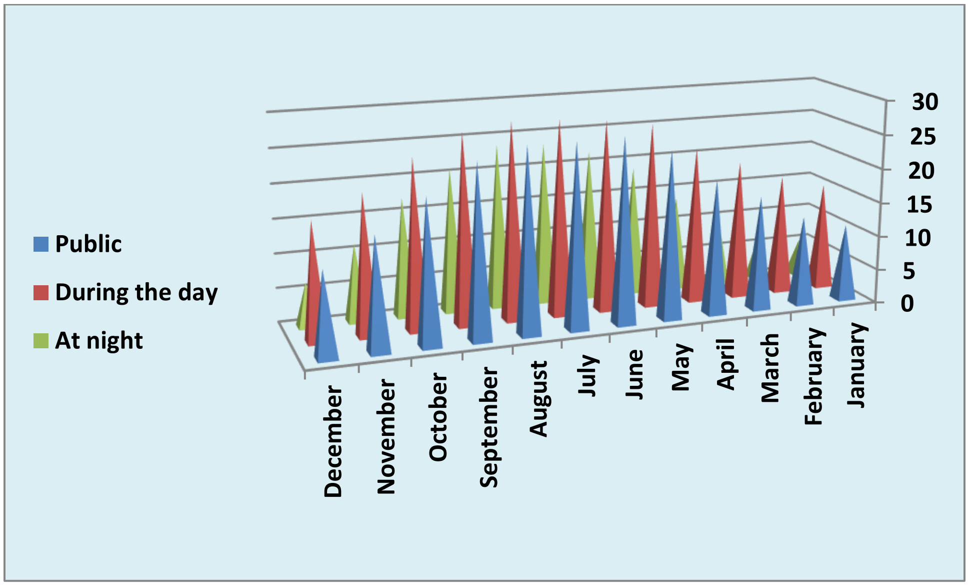

1. General comfort:

Through the results of the monthly distribution of the garlic horn for the climate of the study area and comparing it with the classification limits to determine human thermal comfort in Table (2 (the results confirm the following:

A- The extreme case of major stress that threatens health did not appear, nor did the case of severe discomfort due to heat or cold. Still, the case of moderate thermal discomfort appeared in the months (December, January, February, May, June, July, August, and September) (12.3, 11.1, 13, 24.4, 26.9, 26.7, 26.7, 25), i.e., the months of winter and summer, noting the differences in the level of discomfort. Hence, these two seasons are the least suitable for practicing most activities.

B- The comfortable period climatically was represented by the spring and autumn seasons, as complete comfort was in each of (April and October) (19.6, 20.8), while the relatively comfortable period (inclined For coldness) was represented by the months of (March and November) (16.6, 16.3) This means that the weather is relatively comfortable, so these two seasons are the most suitable seasons of the year for practicing various activities. 2. Daytime rest:

A- The extreme case of great stress that threatens health did not appear during the study period, while the case of severe thermal discomfort appeared in four months of the year, which are (June, July, August, and September) (27.8, 28.4, 28.6, 27.6) respectively, and cases of moderate

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hot discomfort in the months of (May and October) (26.8, 24.6) Therefore, the period of thermal discomfort extends for six months of the year, noting the differences in the level of discomfort, so summer is the least suitable season of the year for practicing various activities in open places where it is difficult to control the elements of the climate, as people suffer from severe discomfort due to the high temperature, so it is preferable to limit the practice of activities to close places through which it is easy to control the elements of the climate.

B- The climatically comfortable period (complete comfort) was represented by the months of (March and November) (20.1, 20.3), i.e., the beginning of spring and the end of autumn, while the relatively comfortable period (tending to be hot) was represented by April only (22.7). The relatively comfortable period (tending to be cold) was represented by each of (December, January, and February) (17.1, 15.6, 17.4), respectively, which means that the weather conditions are relatively suitable for practicing most activities during the winter day.

3. Night rest:

A- The state of great stress that threatens health did not appear. In contrast, the state of severe discomfort due to the low temperatures appeared in each of (December, January, and February) (6.4, 5.2, 6.8), respectively, which shows that the weather conditions at night in winter are somewhat uncomfortable for practicing some activities in open places, as people suffer from severe discomfort due to the bitter cold, so it is preferable to limit most activities to indoor places. Moderate cold discomfort also appeared in (March, April, and November) (10.5, 13.7, 11.3), respectively.

B- The climatically comfortable period (complete comfort) was represented by May (18.8), while the relatively comfortable period was represented by each of (June, July, August, September, and October) (21.9, 23.5, 23.9, 21, 17.3) respectively, noting the differences in the level of comfort, which means that the nights of the summer months are relatively comfortable.

Second - Wind Cooling Index: (k)

Siple and Passel explained the effect of wind on a person's feeling of thermal comfort through its contribution to reducing or increasing body temperature. In cold areas, the effect of wind is clearer, as it works to remove warm air in contact with the body and replace it with cooler air, which leads to increased heat loss from the body. As for hot areas where the temperature exceeds (33°C), wind works to displace the air in contact with the skin and replace it with hotter air, the temperature of which exceeds what is lost from the body due to evaporation, which increases the feeling of heat at a time when the body is most in need of getting rid of its excess heat. Through the wind cooling index, we obtain a great benefit represented in knowing the degree of danger that a person faces in cold and hot weather, and it suggests the types of clothing that should be worn and the types of activities that can be done outside buildings in the open air. The value of the wind cooling index is calculated as follows:

K = (100v + 10.4 – v) (33-ta)

K = wind cooling power, measured in kilocalories/m2/hour

V = wind speed, measured in m/s

ta = air temperature in Celsius

33 = average human skin temperature (bare parts) in Celsius, based on the cooling ratio.

10.4, 100 = constants reached by experiment (Salman, 2021: 494).

In light of the results of this equation, the degree of feeling of cooling or heating resulting from the wind is determined, as the human feeling of comfort is divided according to specific degrees through which the amount of comfort in the human can be known as shown in the following Table:

Table (4) Values of the wind cooling coefficient (k

Sense Of Climate	Symbol	Value
Very Sot	H-	Less Than Zero
Very Hot	∗H	Zero - 50
Hot	H	100 - 50

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Perfect Comfort (Comfortable Warm)	P	200 - 101
Perfect Comfort (Perfect For Comfort)	∗P	300 - 201
Perfect Comfort (Cool Comfortable)	-P	400 - 301
Cold	C	500 - 401
Very Cold	∗C	600 - 501
Very Cold	-C	More Than 600

Source: (Bakr and Rasool, 2023: 449)

When applying the wind cooling guide to the climate of the study area to know the effect of winds on general daytime and nighttime comfort levels, the researcher relied on the monthly wind speed rates with general temperature rates to obtain general comfort and wind speed rates with maximum temperature rates to obtain daytime comfort and nighttime comfort was extracted from wind speed rates with minimum temperature rates. The results appeared in the following Table (5) and Figure (2

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Table (5) Results of applying the wind cooling guide k (general, daytime, nighttime) for the Mishkhab climate station for the period (2013-2023

Night		During The Day		General		Months
Significance	Result Application	Significance	Result Application	Significance	Result Application	
C-Very cold	675	p- Cool comfortable	324	C* Very cold	538.1	January
Very cold C-	614	Cool comfortable p-	322	Cold C	462.2	February
Very cold C*	549	Comfortable (perfect for comfort) P*	210	Comfortable cool p-	398	March
Cold C	453	WarmH	83	Comfortable (perfect for comfort) P*	271	April
Comfortable cool p-	329	Very hot (poisons) H-	-109	Comfortable warm p	101.4	May
Comfortable (perfect for comfort) P*	247	Very hot (poisons) H-	-247	Extremely hot (poisons) H-	-0.7	June
Comfortable warm p	185	Very hot (poisons) H-	-251	Extremely hot (poisons) H-	-36	July

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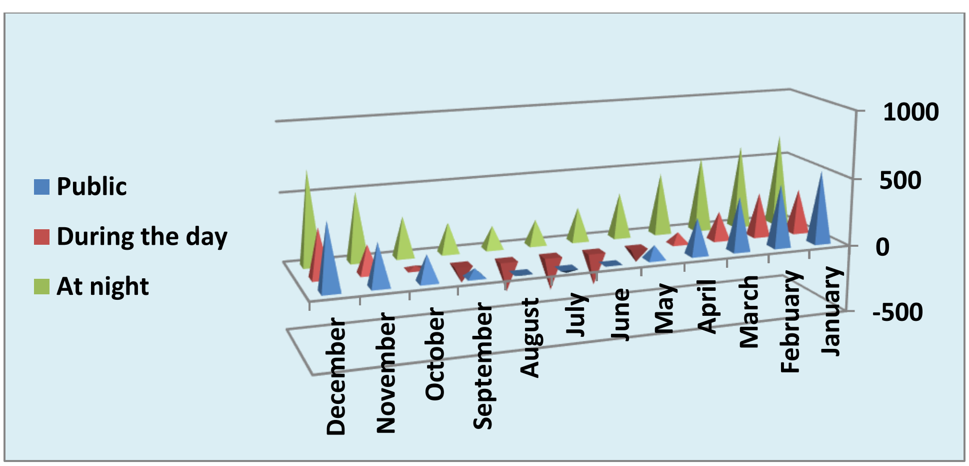
Comfortable warm p	169	Very hot (poisons) H-	-229	Extremely hot (poisons) H-	-23	August
Comfortable (perfect for comfort) P*	223	Very hot (poisons) H-	-131	Warm H	62.4	September
Comfortable (perfect for comfort) P*	296	Very hot H*	26	Comfortable warm p	194	June
Very cold C*	503	Comfortable (perfect for comfort) P*	208	Comfortable cool p-	309	July
Very cold C-	688	Cool comfortable p-	357	Cold C	486	December

Source: The table is the work of the researcher based on Table (4) and Appendix (1). Figure (2) Values of the application of the wind cooling guide k (general, day, night)



Source: Researcher's work based on Table (5)

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From the analysis of the results of the wind cooling index (general, daytime, and nighttime), a clear variation in the rates appears during the months of the year according to the variation in the monthly rates of temperatures and wind speed:

A- General comfort:

A- The monthly rates of the values of the general wind cooling in the winter (December, January, and February) reached (486, 538.1, 462.2) and when comparing these results with the values of the wind cooling index, it became clear that they fall within the climate (cold C and very cold (C*), and the monthly rates for most of the summer months (June, July and August) reached (-0.7, -36, -23) respectively, so they fall under the influence of the very hot climate (H- poisons), while the warm climate H appeared during the month (September 62.4), so it is clear that the effect of the winds during these two seasons is negative on the feeling of thermal comfort.

B- The comfortable climate (ideal comfort *P) appeared In the month of (April 271) only, while the relatively comfortable climate (p- and (p) is represented by each of (March, May, October, and November) (398, 101.4, 194, 309) respectively, noting the differences in the level of comfort.

B- Daytime comfort:

A- The values of daytime wind cooling for the summer months (May, June, July, August, September) reached (-109, -247, -251, -229, -131) respectively, so they are under the influence of the very hot climate (H- poisons), while the climate (very hot H*) appeared in (October 26), and the warm climate H in the month of (April 83), which means that the effect of the winds is negative during the day in these months, causing uncomfortable weather.

B- The comfortable climate (perfect comfort *P) appeared in the months of (March November) (210, 208), i.e., the beginning of spring and the end of autumn, while the relatively comfortable climate (tending to be cold p-) was represented by the months of (December, January and February) (357, 324, 322) respectively, and this means that the effect of the winds is relatively positive during the day in the winter months. T- Night comfort:

A- The results of the wind cooling index during the night for each of (December, January, and February) showed (688, 675, and 614) respectively, so these months fall within the climate (very cold -c), while the months (March, April, and November) vary in the severity of their coldness between the climate (very cold *c) that appeared in each of (March 549 and November

503). The climate (cold c) of the month (April 453) indicates the lack of thermal comfort in these months due to the negative effect of the winds in the study area, which makes the feeling of coldness more than what is recorded in the thermal scales.

B- The wind cooling index in each of (June, September, and October) reached (247, 223, 296) respectively, which indicates that the climate is comfortable (ideal comfort *P) during the night in these months, while the wind cooling index at night for the month of (May) reached 329, which is thus within the relatively comfortable climate (tending to coolness p-). The value for the months of (July) reached 185 and August 169, meaning the dominance of the relatively comfortable climate (tending to heat p), and it is clear from this that the effect of the wind is positive during the nights of these months.

Conclusion

1- The geographical and astronomical location of the study area controls the highlighting of the thermal differences between the year's seasons.

2- The thermal balance between the human body and its environment is related to environmental factors (climatic) and subjective factors (physiological).

1. When comparing the results of the monthly distribution of climate indicators with the classification limits of human thermal comfort, the case of thermal extremism, represented by the case of great stress that threatens health, did not appear. In contrast, the case of severe thermal discomfort appeared clearly during the days of the summer months (severe heat discomfort "poisons") and the nights of the winter months (severe discomfort "bitter cold"), so these two seasons are the least suitable for practicing most types of activities in open places where it is difficult to control the elements of the climate, as people suffer from severe thermal discomfort, so it is preferable to limit the practice of activities to indoor places. 2. The results of applying thermal comfort indicators in the study area showed that the most suitable times for practicing various activities were represented by the spring and autumn seasons of the year, the days of the winter months, and the nights of the summer months, which were characterized by relative comfort. 3. The climatic seasons of the year were represented based on the results of applying the thermal comfort indicators by (December, January, and February) which represented the winter season, and (March and April) the spring season, while the summer season was represented by (May,

June, July, August, and September), and the fall season by (October and November).

4. The thermal conditions inside are affected by the thermal conditions outside, which affects the extent of its need for cooling in the summer and heating in the winter. In contrast, their needs decrease or disappear during the spring and fall seasons.

5. Temperature is the most influential element among the climate elements due to heat's direct effects on humans.

Recommendations:

1. Work on continuous coordination between the climate-related authorities and other authorities (governmental and non-governmental) to link various human activities and events with human thermal comfort and link vacations to the months of heat discomfort to avoid damage affecting human life.

1. Avoid exerting physical effort during the summer months in the study area, especially during the summer days, to avoid fainting and severe sunstroke.

2. When the solar radiation is very bright, it is preferable to use fixed umbrellas on the head and provide easy-to-install and disassemble canopies after completing the work.

3. Drink plenty of water and fluids to resist the intense heat during the hot summer day in the study area and avoid direct sunlight.

4. Work on planting trees around buildings and in gardens and parks because their shade blocks the sun's rays and allows the passage of low-temperature air due to its contact with plants and not hot surfaces.

5. The windows should be designed at an angle of (45°) to allow the largest amount of air to pass into the building and its rooms.

6. Since the period of thermal discomfort in the study area extends for eight months a year, it is necessary to work on providing a suitable climate environment inside and outside the buildings to achieve comfort and freedom, increase efficiency, and thus contribute to increasing production and driving the wheel of economic development in the country.

7. Conduct studies to clarify the extent of outdoor thermal conditions' impact on people's health status, especially those with cardiovascular and respiratory diseases.

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Appendix (1) Monthly rates of the most important climate elements affecting thermal comfort at Al-Mashkhab Climate Station for the period (2013-2023)

	June	May	April	March	Fb	Jn	الشهر العنصر
	666.6	654	600	488	401.1	290.8	كمية الاشعاع الشمسي
	33.0	28.7	21.6	17.2	12.6	10.3	درجة الحرارة
	41.3	37.3	29.5	24.2	19.3	16.3	درجة الحرارة العظمى
	24.6	20.1	13.7	10.1	5.9	4.5	درجة الحرارة الصغرى
	2.1	1.7	1.4	1.5	1.4	1.5	سرعة الرياح م/ ثا
	30.4	38.0	46.2	51.4	52.1	60.9	الرطوبة النسبية
	51.4	60.7	73.7	77.8	79.1	85.2	الرطوبة النسبية العظمى
	9.4	15.4	18.6	24.9	25.1	36.5	الرطوبة النسبية الصغرى

Source based on:

.1Ministry of Transport, General Authority of Meteorology and Seismic Monitoring, Climate Department, unpublished data, Baghdad, 2023.

.2Ministry of Agriculture, Agricultural Meteorology Network, data published on the website www.agromet.gov.iq //http: ,.2024