# Impact of Extreme Heat and Dust Storms on the Urban Residents of Baghdad, Iraq

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## Abstract

Currently, there is a lack of acknowledged evidence about the correlation between dusty or extreme heat conditions and comfort levels in Iraq and the Gulf region. This material aids in comprehending the effects of orange dust and high temperatures on human well-being and physical conditions. This study examines the interaction between natural comfort and commuter responses, specifically focusing on their suitability in varying climatic circumstances, such as dusty sky, as observed during the field survey.

The study was done in the city of Baghdad to investigate field measurements of micro-climatological parameters. It provides an overview of the connection between human comfort and the combined effects of heat and dusty conditions**.** A statistical analysis was conducted to examine the impact of heat conditions and air dust on comfort, using daily and hourly average data. The province of Baghdad and its surrounding territory had an average daily dust deposition of 3.597 mg/m2, resulting in a total dust accumulation rate of 67,176 mg/m3/day**.**

The findings indicate that the presence of orange dust leads to a notable reduction in energy levels, with an average decrease of 40%. During the summer period, which spans from May to September, temperatures rise 46°C and above These significantly diminish the overall comfort level. The findings of the interview indicate that over 90 % of the societal segments believe that heat and/or dust storms have a detrimental effect on people's comfort, health, and daily activities. Severe heat and dust storms are commonly attributed to climate change.

**Keywords:** Thermal comfort, Dust storm, Community survey, Microclimate factors, severe heat.

## Introduction

Climate change is associated with increased temperatures, droughts, atmospheric dust storms, and subsequent implications for human health risks. At the same time, satisfaction of people with the quality of their immediate environment, particularly in terms of thermal conditions, humidity levels and cleanliness, holds a great importance. These factors have the potential to pose threats to the well-being and survival of both people and animals. For example. the standard range for normal human body temperature is 36.5–37.5 °C. Once an individual's body temperature reaches this range, they are considered to have achieved normothermia and can maintain stability within this temperature range. In order to maintain normothermia in people, it is necessary to minimize metabolic exertion, while also considering the influence of temperature, humidity, and cleanliness on achieving sustainable human existence. In fact, in certain civilizations, the concepts of coolness and warmth also have acquired symbolic significance, representing holiness, communal bonds, and security.

Any combination of heat, humidity, and a dusty atmosphere has the potential to diminish both human comfort and environmental quality (Fang et al., 2004). When alterations in thermal neutrality or atmospheric cleanliness occur, individuals may experience a sense of discomfort and interpret it as unpleasant (Parkinson et al., 2014). However, urban environmental design must rise up to meet the demands of thermal comfort during the outdoor activities in metropolitan areas. The concept of sustainable cities highlights the importance of creating green spaces outside that are conducive to the comfort and engagement of commuters in various activities. Indeed, outdoor facilities need to be provided with sustainable comfort for people (Nasir et al., 2012).

In this context, providing thermal comfort in outdoor environments, particularly in urban regions with high temperatures is crucial. This phenomenon can be attributed to the consequences of anthropogenic global warming resulting from urbanization (Hasson et al., 2013). The divergence of solar radiation influx results in the occurrence of warm Eastern winds over the elevated region throughout the summer months. Conversely, the Western sides experience the infiltration of chilly air, leading to shifts in the West-to-East weather pattern across Iraq.

The incorporation of poorly designed green land cover into modern designs, with the intention of achieving good sustainable performance, presents an additional drawback. This phenomenon can be attributed to the escalating intensity of surface winds, leading to wind-induced soil erosion. While the main purpose of urban green spaces and buildings is to offer protection and improve comfort, they are also associated with several factors related to urban outdoor and building air pollution, heat, noise from local energy generators, harmful dust particles, and mental health consequences (Anderson et al., 2009).

In terms of thermal comfort, this study explores the subjective experience of people in relation to their thermal environment, specifically focusing on the sensation of well-being that arises from a favorable thermal state. Its aim is to gain insights into the impacts of extreme heat and dust storms on the well-being of urban residents in Baghdad, with a focus on understanding the broader, long-term implications on human comfort and health. It seeks to explore the overarching connections between climatic conditions, societal well-being, and environmental quality, aiming for a comprehensive understanding of the complex dynamics at play.

Its objectives are:

1. To establish the urgency for adaptive measures and recommend interventions for sustainable urban planning in response to climate change challenges in Baghdad.
2. To propose a cost-effective approach for evaluating human comfort, integrating insights from statistical analysis and field surveys.

## Review of Literature

A lot of research have been conducted into thermal comfort. Among them a number of themes have emerged. For example, Fang et al. (2004) and Parkinson et al. (2014), show that thermal comfort includes factors such as temperature, humidity, and cleanliness. They say that it is essential to understand how people perceive and respond to their immediate environments. On the other hand, Hasson et al. (2013) and Robock (2019) emphasize the connection between rising temperatures, dust storms, and adverse health effects, particularly respiratory issues. Nasir et al. (2012) and Anderson et al. (2009) contribute to the understanding of the challenges associated with urban green spaces, including air pollution and its impact on comfort. They articulate strategies for creating urban environments conducive to well-being. Similarly, Spracklen et al. (2008) and Hasson (2008) examine how dust storms influence Earth's energy balance, emphasizing the direct and indirect effects on radiation dispersion and absorption. They focus on microclimatological parameters such as air temperature, relative humidity, wind speed, and dust density. Nicol and Humphreys (1973) and Sangkertadi and Syafriny (2012) establish the relationship between comfort levels and temperature variations. Nicol et al. (1999 and Nicol et al. (2006) extend the examination of thermal impact on human health, drawing on previous research demonstrating the correlation between elevated outdoor temperatures and mortality rates. They argue that understanding the health consequences of extreme temperatures, including respiratory disorders and other ailments, contributes to the design of outdoor spaces that will provide good thermal comfort. They provide the context of this study.

## Research Methodology

This study examines various factors contributing to the energy balance of the Earth, including global radiation, surface albedo, reflected radiation, incoming shortwave radiation, the ratio of real sunshine hours to total hours, wind speed, relative humidity and rainfall. The climate of Iraq is predominantly characterized by dry and semi-arid conditions, with principal features including low humidity, considerable diurnal temperature differences, hot summers characterized by hot, dry winds, and cool winters with cold, dry winds. These conditions are predominantly seasonal in nature. The relevant data is presented in the Table 1.

Data was collected under the guidance of the research department at the Central Iraqi Weather Bureau, specifically at the Baghdad Station. Field measurements were taken during the calendar year 2021. The study involved collecting monthly average values of hourly mean air temperature, obtained using shielded copper-constantan thermocouples. Dust density on polythene sheets, placed on the ground surface throughout day and night hours, was measured at one-hour intervals for each day. The average density of dust particles and TSD was then determined through measurements.

A comprehensive field study in Baghdad measured the micro-climatological parameters related to extreme heat and dust storms. A detailed statistical analysis, using daily and hourly data, assessed the impact on human comfort, specifically addressing an average daily dust deposition of 3.597 mg/m² and a total dust accumulation rate of 67,176 mg/m³/day. Health risks associated with PM10 micro sand particles were investigated, aligning with the mean hourly concentration of Total Suspended Dust (TSD) ranging from 2 to 4 grams per cubic meter per hour in the Baghdad Metropolitan area. Moreover, an interview survey with 172 commuters gauged the perceived impact on comfort, health, and daily activities. Correlations between climatological parameters and commuter behavior were explored, contributing to a nuanced understanding.

**Table 1:** The weekly mean of daily average weather factors data for the project in the study period
Source: Author

| Months | Air Temperature C | Global Solar Radiation MJm² | Relative humidity % | Sunshine hours | Wind speed m/s |
|---|---|---|---|---|---|
| Jan | 11.4 | 2.4 | 51 | 6.1 | 5 |
| Feb | 16.1 | 3.7 | 44.1 | 7 | 4.7 |
| Marc | 17 | 5.4 | 34.9 | 8.1 | 3.8 |
| April | 20.3 | 7.3 | 31 | 7.1 | 0.4 |
| May | 21.8 | 7.7 | 27.5 | 7.3 | 1 |
| June | 35.4 | 9.4 | 25.1 | 13 | 2.2 |

| | | | | | |
|---|---|---|---|---|---|
| July | 41.2 | 9.7 | 23 | 12.6 | 1.4 |
| Aug | 40.4 | 8 | 22.3 | 11.3 | 0.3 |
| Sept | 33.4 | 6.5 | 22.8 | 11 | 0.2 |
| Oct | 23.5 | 6.4 | 22.1 | 11.4 | 2.1 |
| Nov | 14.4 | 4.6 | 40 | 10.5 | 3 |
| Dec | 11.6 | 3.5 | 42 | 8 | 2.8 |

## Results and Discussion

### Dust Storms Impact

According to the observations, dust storms occur due to powerful winds that lift loose sand particles from the desert areas, depositing them at high altitudes in the atmosphere. The region of Baghdad has witnessed the deposition of orange dust particles, affecting air quality and increasing temperatures due to shifts in weather patterns. PM10 micro sand particles, with a diameter of less than 10 µ, can penetrate the respiratory system, leading to severe health complications such as asthma, heart, and lung ailments. The impact of dust particles extends to the environment, contributing to decreased air quality and reduced visibility. These particles pose significant health risks, especially for individuals with pre-existing respiratory conditions, potentially resulting in long-term adverse health outcomes. Dust storms can significantly impair visibility, making driving conditions hazardous and potentially leading to tragic consequences. The mean hourly concentration of TSD in the Baghdad Metropolitan area from May to August ranged from 2 to 4 grams per cubic meter per hour. The observed uneven concentration is likely attributed to variations in meteorological factors throughout the data collection period, aligning with findings reported by Hasson (2008).

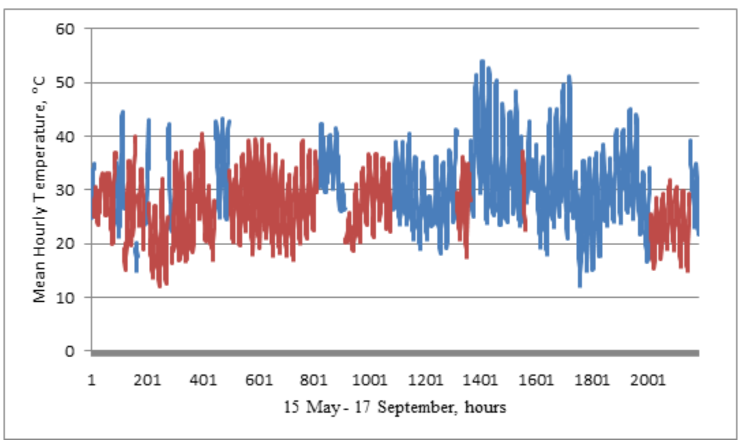


**Fig. 1:** Hourly mean temperature for the project in the study period
Source: Author

### Energy Reduction

As Tegen et al. (1996) Jacobson (2001) and Robock (2019) have recommended, the study measured dust storm properties, global solar radiation, and the effects of diffuse radiation on surface energy, ambient air temperature, and space.

### Experiments

The measurements of solar radiation transmissions were conducted alongside measurements of satellite reflectance using a sun-photometer. Dust storms can have significant effects on the energy balance, modifying various properties. The measured TSD sizes, ranging between 0.001 – 40 microns in the atmosphere, exhibit strongly forward-peaked both direct and indirect effects on Earth's energy balance. The extent to which albedo directly influences space—lowering temperatures—or indirectly, by particles acting as cloud condensation nuclei and altering cloud characteristics, remains uncertain. According to research published in 2008 by Spracklen et al., particles in the atmosphere can directly scatter and absorb radiation. Atmospheric cooling results from radiation dispersion, while atmospheric warming results from radiation absorption.

Enhancement of incoming diffuse flux, caused by enhanced forward diffusing of incoming solar radiation, was observed due to the heavy dust storms. However, around 40% of the total solar radiation dropped during several months (Figs 1 and 2). Solar radiation transmissions were measured alongside reflectance measurements obtained from a sun photometer and satellite. Dust storms have the potential to impact the energy balance and alter several attributes (Hasson, 2017). The TSD measurements indicate that particles ranging in size from 0.001 to 40 microns in the atmosphere have significant direct and indirect impacts on Earth's energy balance, characterized by a pronounced forward scattering pattern**.**

The precise impact of albedo on the space environment, whether through direct cooling effects or indirect influences on cloud properties by serving as cloud condensation nuclei, is still subject to uncertainty. The study conducted by Spracklen et al. (Spracklen et al., 2008) revealed that atmospheric particles possess the capability to scatter and absorb radiation. The phenomenon of atmospheric cooling is attributed to the dispersion of radiation, whereas atmospheric warming is attributed to the absorption of radiation. The augmentation of the incoming diffuse flux is a result of the intensified forwards diffusion of solar energy. The decrease in direct incoming shortwave radiation was nearly equivalent to an accompanying decline. The massive dust storms are the primary cause of this phenomenon. Nevertheless, it is worth noting that around 40% of the overall solar radiation experienced a decline over the course of several months as illustrated in Figures 1 and 2.

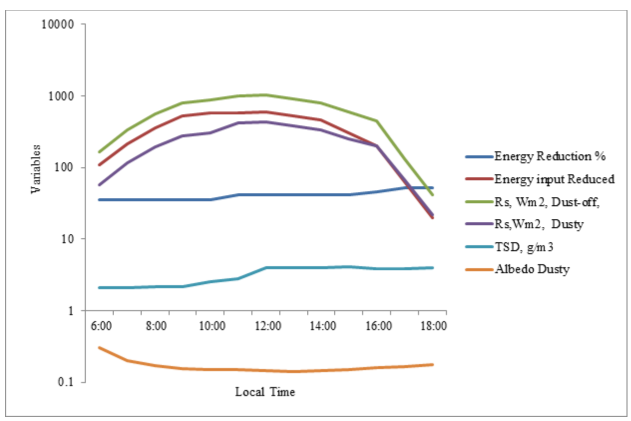


**Fig. 2:** The variation of values of energy input influenced by TSD
Source: Author

There exists statistical variability in the average quantity of energy conserved across the region (Vardoulakis et al., 2014; Anderson & Bell, 2009). The energy input in Baghdad can be substantially influenced by dust storms, resulting in observable statistical consequences. The coefficient depicted in the Figure 2 represents the percentage decrease in energy consumption when a specific meteorological event, such as dust storms, takes place within a particular week. Moreover, it also accounts for any subsequent recovery in comfort levels observed during each week of the summer season. The Figure 3 illustrates the presence of a linear correlation between the observed values. The equation presented in the figure was derived by fitting the data points, resulting in a high coefficient of determination, $R^2 = 0.63$.

Figures 2 and 3 illustrate the observed decrease in air temperature during dust storms, resulting in a significant reduction of heat by 40%. Moreover, the frequency of dusty days was recorded on an hourly basis. The presented figure demonstrates the presence of a linear correlation between comfort levels and the percentage of heat reduction. Data points in the figure were utilized to create an equation, which exhibited a strong correlation coefficient in both regression types, with $R^2 = 0.63$.

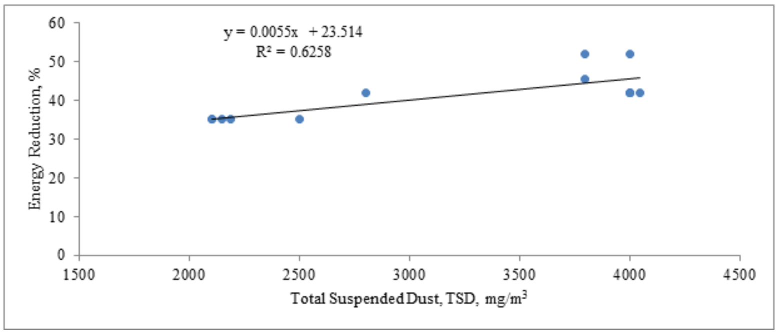


**Fig. 3:** The variation of energy reduction with TSD
Source: Author

## Comfort Survey

A reasonable approach to human comfort to elucidated the manner in which people respond to the thermal and dust environment by considering the natural and physiological processes of heat exchange and dust.

Between June 2017 and March 2018, a comprehensive survey was conducted on a sample of 172 individuals from the local community. This sample included both male and female adults aged 18 to 74 years, as well as elderly individuals aged 75 to 90 years who travel regularly. The findings of the interviews indicate that a significant majority, over 90 %, of the various societal segments residing in Baghdad are susceptible to the impact of heat and/or dust storms. Majority of the commuters believe that climate change is a natural occurrence. Findings also demonstrate that a majority of commuters, specifically over 85%, believe that the occurrence of heat and/or dust storms has a discernible impact on both their small businesses and their overall lifestyle. Two primary inquiries are being addressed. First, commuters express their apprehension regarding the potential consequences of heat and dust storms. Second, the focus is on the impact of these phenomena on people's activities and lifestyles.

In September 2018, a survey was conducted through personal intercepts to ascertain whether commuters engaged in critical thinking and to evaluate the impact of heat and/or dust storms on health, symptoms, comfort, activity, and lifestyle. The sample for this study consisted of urban residents residing in the Jaderia area, selected to reflect a diverse range of adult, female, male, and elderly individuals. The study questions elicited a cumulative response of 172 replies. The analysis was conducted using numerical analysis techniques, specifically employing SPSS software. The data were subjected to analysis based on their frequencies. Given the uneven sample sizes of the subgroups, the percentage technique was employed.

**Table 3:** Results of the questionnaire by different sectors of the Baghdad population
Source: Authors

| Group | Health | | Wellbeing | | Size |
|---|---|---|---|---|---|
| | N | % | N | % | |
| Adult female | 12 | 26 | 30 | 75 | 42 |
| Adult male | 5 | 10 | 45 | 90 | 50 |
| Elderly female | 18 | 51.4 | 27 | 77.2 | 35 |
| Elderly male | 33 | 73 | 12 | 26.7 | 45 |

Observations indicate that due to the recent prolonged heat and the presence of orange dust, all urban residents were affected by heat and dust storms. Specifically, 51% of elderly individuals, 73% of females, and 73% of males reported health complaints, contrasting with 26% of adult females and 19% of adult males, as illustrated in Table 3.

**Table 4:** The heat or/and dust storm affected on daily activity
Source: Author

| Commuter group | % Agree | % Disagree |
|---|---|---|
| Adult female | 90 | 7 |
| Adult male | 100 | 0 |
| Elderly female | 82 | 17 |
| Elderly male | 90 | 10 |

In general, the findings of the survey revealed that a significant proportion of people had issues with their physical well-being, level of comfort, and everyday functioning, which were impacted by both high temperatures and the presence of orange dust. The research findings unveiled a prevalent pattern of consensus among the interview participants regarding the impact of climate change, particularly in relation to high heat, dust storms, and drought. The relevant data is presented in Table 2. Elderly individuals experiencing typical symptoms during heat or dust storms are at an increased susceptibility to respiratory disorders, including asthma, bronchitis, and emphysema, as well as diabetes and heart diseases. Meanwhile, the adult population expresses dissatisfaction with the discomfort and adverse effects on ocular health, along with concerns regarding the impact on local small enterprises. The nation necessitates extensive and enduring efforts in rehabilitating infrastructure, developing sustainable practices, and conducting research on afforestation, sustainable building, and mitigating the impacts of climate change.

## The City of Baghdad and Its Human Comfort

Iraq is characterized by three primary climatic areas: arid desert, semi-arid steppe, and moist highland terrain. Baghdad, a metropolis situated in the central region of Iraq, is home to a population of approximately 8.8 million individuals. The desert region exhibits high aridity and elevated temperatures, with average diurnal temperature fluctuations ranging from 25°C to 43°C during the summer season and decreasing to 4°C to 17°C during the winter season (Hasson et al., 2017).

The steppe region experiences high temperatures, with average daily temperatures ranging from 26°C to 50°C during the summer season and dropping to 5°C to 18°C during the winter season (Hasson, 2008; Tegen, 1996). Within the mountainous region, the climate is characterized by lower temperatures and higher levels of precipitation compared to the steppe zone. During the summer season, the diurnal temperature exhibits a range of 27°C to 44°C, while in the winter season, it varies between 4°C and 15°C. Relevant information on the topic is available on the website ESA.UN.org, as referenced in source (Fanack, 2018).

The primary elements that significantly impact comfort levels in Baghdad are the heat emitted by surrounding surfaces, the occurrence of dust storms, the air quality in urban areas, and the subsequent implications for human health. These factors not only influence comfort but also present potential opportunities for implementing measures to protect and promote public health. Understanding and addressing these elements are crucial for developing strategies that enhance the well-being and comfort of the city's residents.

## Thermal Impact

This research reveals that the yearly average of daily mean temperatures recorded in Baghdad indicates a notable long-term increase of 7% over the past five decades (Hasson et al., 2013). Episodes of excessive heat can have detrimental effects on human well-being, potentially resulting in fatalities and inducing physiological and psychological strain. Extreme weather events also have the potential to attract detrimental insect species, while diseases can give rise to infections and airborne bacteria and viruses.

Severe conditions, particularly during the summer months can lead to respiratory organ disorders due to air pollution, especially among people with pre-existing lung ailments. Climate change has the potential to elevate the levels of air contaminants, including organic and volatile components. Understanding and addressing these thermal impacts are essential for safeguarding public health in the face of changing climate conditions.

Previous research has established a correlation between elevated outdoor temperatures and mortality rates (Hajat et al, 2014). According to them, people with pre-existing medical conditions such as mental disorders, neurological or cardiovascular diseases, as well as those who are overweight or have limited mobility, are more susceptible to adverse health effects during extended periods of high heat and heatwaves. Understanding and addressing the specific vulnerabilities of these people are crucial for developing effective strategies to mitigate the health impacts of rising temperatures.

Thermal comfort is typically affected by factors such as temperature, humidity, and perceived air quality, which are influenced by sensory loads. Moreover, it has been established that thermal comfort is associated with societal accomplishments, as evidenced by task performance assessments (Hasson, 2008). Regression equations have been effectively formulated using data obtained from real-world observations, field monitoring, and statistical analysis, accurately depicting a standard course of action. The thermal reaction corresponding to integer values of comfort is presented in Table 5. In their publication, the authors (Sangkertadi and Syafriny, 2012) presented a comprehensive analysis of comfort values and the methodology used to assess levels of reception.

**Table 5:** The comfort vote and comfort reception based on the PMV scale
Sangkertadi and Syafriny, 2012

| Comfort Value | Comfort Level Reception |
|---|---|
| -2 | Cold |
| -1 | Cool |
| 0 | Comfort/Neutral |
| 1 | Warm/Slightly Hot |
| 2 | Hot |
| 3 | Very Hot |
| 4 | Severe Heat |
| 5 | Feel Pain |

## Comfort Determination

The statistical analysis in this study examined the influence of micro-climatological parameters on commuters' behavior and their perception of comfort. The findings indicate a positive correlation between the comfort factor and commuters' conduct, suggesting that they respond favorably to the environmental circumstances in the study area. The statistical analysis utilized a dataset consisting of natural conditions, specifically focusing on the measured air temperature, relative humidity, air velocity, and dust concentration to ascertain the level of comfort. Similar to previous studies (Sharma and Ali, 1986), a statistical analysis approach was employed. However, it should be noted that this method exhibited limitations in accurately measuring environmental conditions, particularly when attempting to apply it to diverse locations or conditions, leading to numerous errors in establishing relationships between variables (Spracklen et al., 2008; Humphreys and Nicol, 2000). The average thermal comfort values ranged from 0.0 to +2.3 during the dust-off period, while the values for dusty air space ranged from -0.003 to +1.50.

The data were obtained throughout the summer season, resulting in notable fluctuations in comfort conditions during the summer months. The analysis of Figure 4 reveals a significant correlation between the slope of the regressions for (A) dusty-off and dusty skies. This finding suggests that certain outcomes can be attributed to the combined effects of heat and a clear sky. The energy intake of this product does not have any bearing on the occurrence of a dust-off sky. According to Nicol and Humphreys (Nicol and Humphreys, 1973), the impact of local temperature on comfort levels varied across different climates to a lesser extent than anticipated. The variability in comfort levels with heat between different surveys is typically significantly lower than the variability observed within a single survey (Lau et al., 2019).

The study findings indicate a strong correlation between the comfort temperature and the average temperature recorded in both dust-free and dusty conditions during field surveys (Figure 4). Similar findings were reported by Nicol et al. (Nicol et al., 1999; Nicol et al., 2006), where they observed a consistent effect when data was collected over the course of the entire year from a specific category identified in a previous study (Kinne et al., 1997).

The predominant means by which the Iraqi population has sought to regulate their comfort levels was through the manipulation of the frequency and concentration of environmental dust particles. Figure 4 illustrates the average probability of comfort, computed using regression analysis. Each data point reflects the proportion of individuals who reported feeling comfortable in a specific city during a specific month. The correlation coefficients ($R^2$= 0.80 and 0.52) indicate a significant and positive association between the dusty-off environment and the mean comfort temperature, as well as between the dusty environment and the mean comfort temperature, respectively, as illustrated in Figure 4.

The findings of the study indicate that there was no significant difference in the health consequences between heat waves and dust storms in Baghdad. However, it was observed that dust storms had a more pronounced impact on individuals' health compared to heat waves.

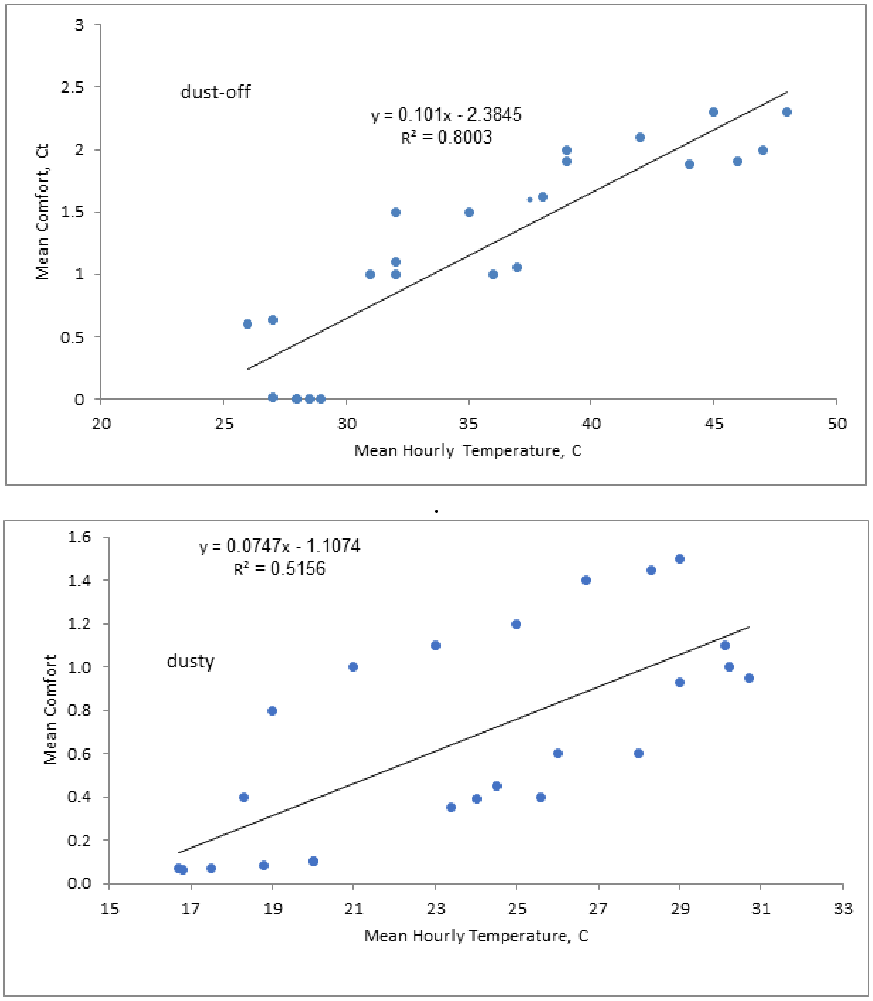


**Fig. 4**: Relation of dust-off skies and dusty summer monthly average of hourly mean air temperature and mean comfort

The measured hourly mean comfort and the heat with dust-off and dusty skies for the monitoring period are shown in Figs. 5 and 6. The existence of linear relationships between the values is illustrated in Fig. 5. The concluding equation was formed with significantly high correction coefficients for dust-off and dusty environments ($R^2$ = 0.68 and 0.91, respectively). These values plotted the thermal comfort temperature against the dusty-off and dusty hourly mean temperature from a number of surveys conducted among many commuters.

**Table 6:** Correlation values of comfort and temperature variables

| Variables | Intercept (a) |
|---|---|
| Mean Comfort x Mean hourly Temperature (Dust-off) | 0.1 |
| Mean Comfort x Mean hourly Temperature (Dusty) | 0.07 |
| Mean Comfort Temperature x Mean hourly temperature (Dust-off) | 0.71 |
| Mean Comfort x Mean hourly Temperature (Dusty) | 0.58 |
| Mean Energy Reduction x TSD | 0.005 |

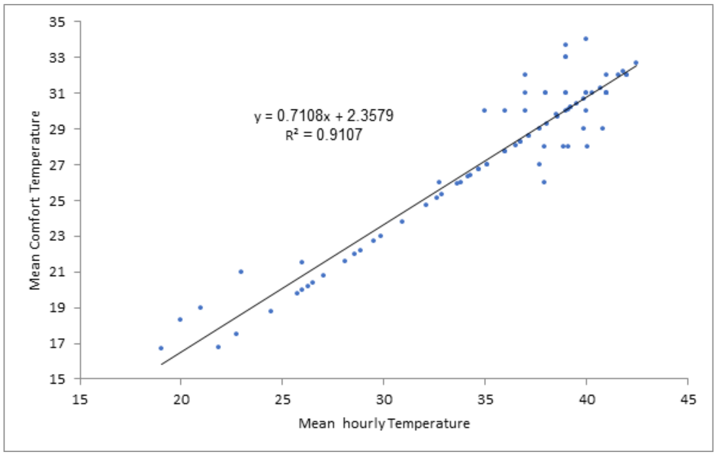


**Fig. 5:** Relations between mean hourly temperature with mean comfort temperature for the period of three days (72 hrs) dusty day.

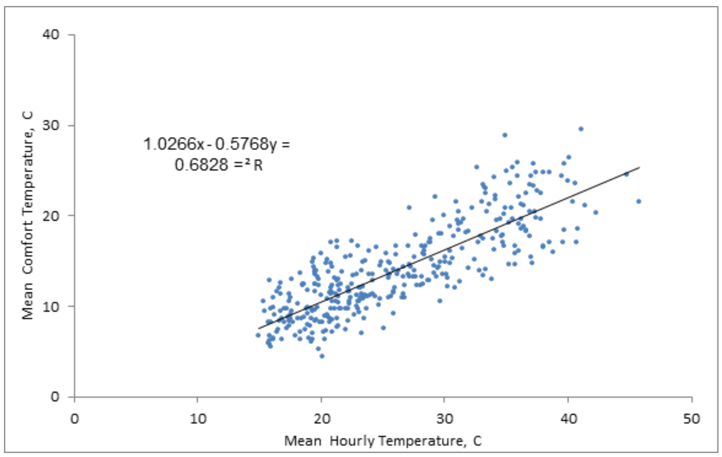


**Fig. 6:** Relations between mean hourly temperature with mean comfort air temperature for the period of May–August (80 days).

The calculation of comfort temperatures relies solely on outdoor temperature; however, it is evident that the concept of comfort temperature encompasses additional factors. The findings of the study suggest that there is no substantial variation in the percentage of production loss caused by meteorological conditions across the territory. However, it is noteworthy that there is a statistically significant difference in the impact of heat waves and humidity across the region.

The calculations for the climatological variables that exhibit a statistically significant impact on comfort are presented in Table 6. Based on the analysis, we fail to reject the null hypothesis that the influence of heat from meteorological conditions is greater than that of dusty storms. Climate change has had a substantial impact on human comfort in relation to heat and dust. According to the input received, it is suggested that in real-time scenarios, only the concentration of orange dust should be taken into consideration when comparing the factors between severe weather and adaptive actions.

Extensive literature exists on the correlations between comfort and temperature, although there is a dearth of research investigating the association between comfort and a dusty atmosphere (Spracklen et al., 2008; Sharma and Ali, 1986). Currently, there is a lack of acknowledged evidence about the correlation between dusty or extreme heat conditions and the level of comfort experienced in Baghdad, Iraq, and the wider Gulf region. This knowledge aids in comprehending the effects of orange dust and high temperatures.

The primary aim of regressing comfort on temperature is to identify a cost-effective and straightforward approach for evaluating human comfort in locations where relevant data is available. This estimation technique can be applied in microclimatological studies pertaining to sustainable environments, particularly those focused on human health and sustainable building and urban designs. Another purpose of this study is to analyze the nature of the linkages between heat fluxes in severe heat and dusty environments. The hourly values of daytime temperatures and comfort in the Baghdad region throughout the summer period was discussed, specifically focusing on the dusty and dust-off hours. The regression constants and correlation coefficients are computed and presented in Table 5.

The regulation of urban spaces in response to outdoor climatic conditions, as well as the involvement of individuals and government, plays a significant role in mitigating the causes of climate change. For instance, the practice of afforestation demonstrates effective insulating properties and promotes the widespread adoption of renewable energy sources. Implementing such measures not only contributes to climate change mitigation but also enhances the overall sustainability and resilience of urban environments.

## Conclusions

This manuscript delves into the multifaceted impact of extreme heat and dust storms on the urban residents of Baghdad, Iraq. The study explores the intricate relationship between microclimatological parameters, thermal comfort, and the health and well-being of the populace. The research, conducted in the city of Baghdad, emphasizes the significance of understanding the combined effects of high temperatures and dust storms on human comfort and environmental quality.

The findings reveal a substantial daily dust deposition in the region, with a consequential impact on energy levels, resulting in a noteworthy average decrease of 40%. The prevalence of elevated temperatures during the summer months further diminishes overall comfort levels. The interview survey among 172 commuters underscores the widespread belief, with over 90 % of participants, that heat and/or dust storms detrimentally affect people's comfort, health, and daily activities. Climate change, particularly manifested through severe heat and dust storms, is acknowledged as a contributing factor by the majority. Analyzing the impact of dust storms, the study demonstrates their adverse effects on air quality, visibility, and health, with PM10 micro sand particles posing significant risks, especially to those with preexisting respiratory conditions. The research also highlights the influence of dust storms on the energy balance, leading to a substantial reduction in energy consumption during specific meteorological events.

Thermal impact of extreme weather events, such as heatwaves and dust storms is discussed, revealing a notable long-term increase in daily mean temperatures. The study emphasizes the importance of understanding and addressing these thermal impacts for safeguarding public health in the face of changing climate conditions. A comprehensive survey among urban residents reinforces the significant impact of both high temperatures and the presence of orange dust on physical well-being, comfort, and daily activities. The statistical analysis indicates a positive correlation between microclimatological parameters and commuters' behavior, suggesting that people respond favorably to environmental circumstances. It finally proposes a cost-effective and straightforward approach for evaluating human comfort in locations with available data, particularly in the context of sustainable environments.

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