6. ENVIRONMENTAL PARAMETERS AND INDICES

6.1 Environmental parameters

Environmental parameters that affect human comfort can be categorized into:
(a) directly measured parameters and (b) calculated parameters.

The following are the frequently used directly *measured psychrometric parameters:*

• Dry-bulb temperature.
• Wet-bulb temperature.
• Dew-point temperature.
• Water vapour pressure.
• Total atmospheric pressure.
• Relative humidity.
• Humidity ratio.
• Air velocity.

The mean radiant temperature is derivable and, hence, a *calculated parameter*. It is the temperature of a uniform black enclosure in which a solid body or occupant would exchange the same amount of radiant heat as in the existing non-uniform environment. Fanger identified two additional calculated parameters, which are *activity level* and *clothing*. In addition to the above, the other secondary factors such as day-to-day temperature variation, age, adaptability, sex, etc. also influence comfort.

6.2 Environmental indices

An environmental index combines two or more parameters, such as air temperature, mean radiant temperature, humidity or air velocity into a single variable. The *effective temperature* (ET*) is probably the most common environmental index and has the widest range of applications.

The *effective temperature* (ET*) is defined as the dry-bulb temperature of a uniform enclosure at 50% RH in which humans would have the same net heat exchange by radiation, convection, and evaporation as they would in the varying humidities of the test environment.

Another approach used to evaluate the combined effect of temperature and humidity is the *Heat Stress Index*. This index is the ratio of the total evaporative heat loss required for thermal equilibrium to the maximum evaporative heat loss possible for the environment, multiplied by 100 for steady-state conditions (skin temperature is held constant at 35°C in order to limit the rise in body temperature, the sweat rate should not exceed one litre per hour to limit the loss of body fluid). The heat stress index is therefore defined as:

$$Heat\ stress\ index = \frac{\dot{Q}_E}{\dot{Q}_{E,max}} \times 100$$

$\dot{Q}_E$: the actual evaporation rate

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$\dot{Q}_{E,max}$: the maximum evaporative heat loss with the skin temperature at 35°C.

7. COMFORT CHARTS

In identical environments, different people perceive comfort in different ways. In the same built environment, some may feel chilly while others may feel warm. Likewise some people tend to like moist coastal climate, while others may prefer arid desert environment or cool and crisp mountain weather. Dry bulb temperature is not a reliable indication of how warm or cold an occupant will feel in a room. The effects of both relative humidity and air velocity need also to be considered.

In the same context, ASHRAE and other researchers have conducted extensive research over the years to relate the above factors to human comfort, as shown in figure 3. From the results of these tests emerged the concept of an *effective temperature*. This index is a measure of comfort which involves the combined effect of dry bulb, wet bulb, and air movement as judged by the subjects in the research studies. There were a number of different combinations of dry-bulb and relative humidity which would give the same feeling of comfort to a high percentage of the subjects for a given air velocity. All these combinations were said to have the same effective temperature, defined earlier. See figure A typical comfort chart shown in Figure 3.4 could then be constructed by drawing lines through the points at which **the majority of people equally clothed and equally active reported the same feeling of comfort**. These lines are called the ***effective-temperature*** **(ET)** lines. The summer-comfort zone ABCD encompasses the possible combinations of dry-bulb temperature and relative humidity which produce summer comfort for most people. It may be noted that this zone spans the range of effective temperatures from around 19 to 24°C. In a like manner, the area EFGH is the winter-comfort zone for most individuals and spans the range of effective temperature from 17°C to 22°C.

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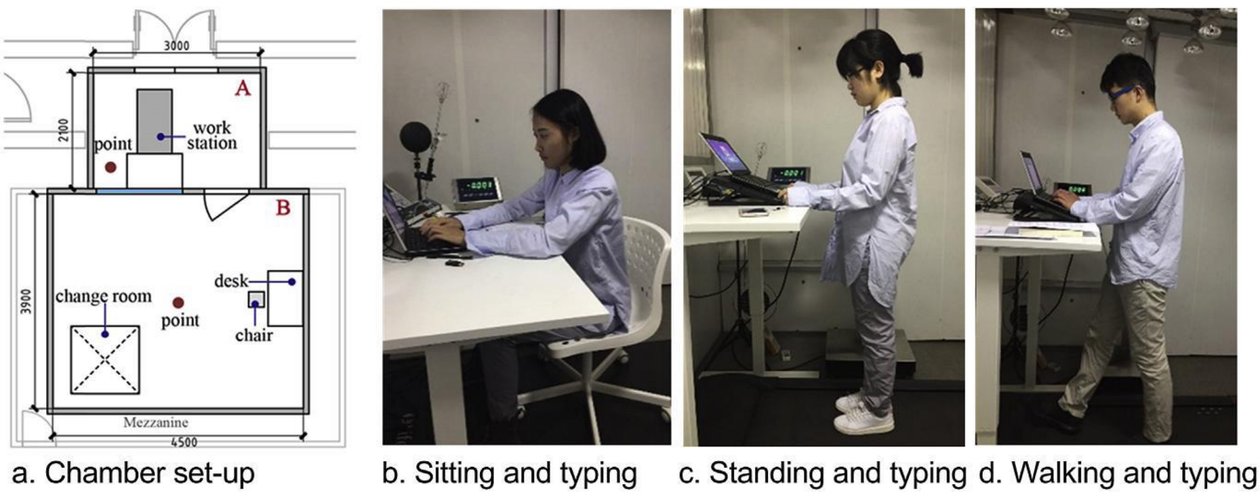

Figure 3a climate chamber for comfort study

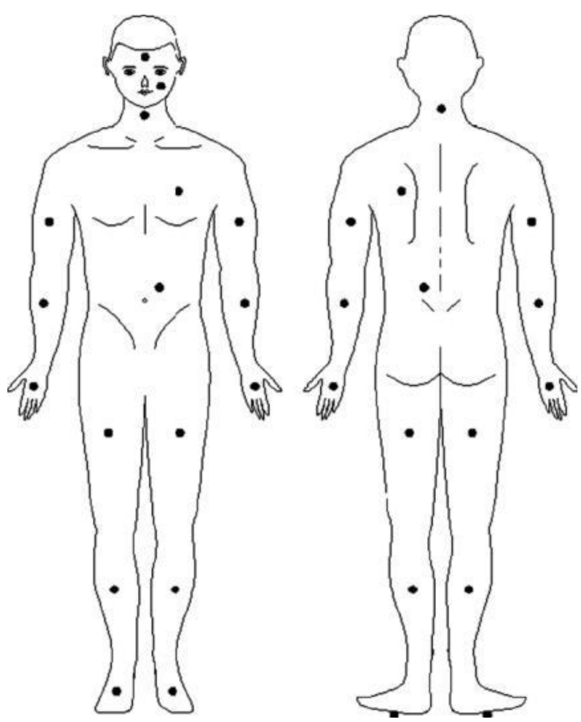

Figure 3 b, the Measurement points of local skin temperature.

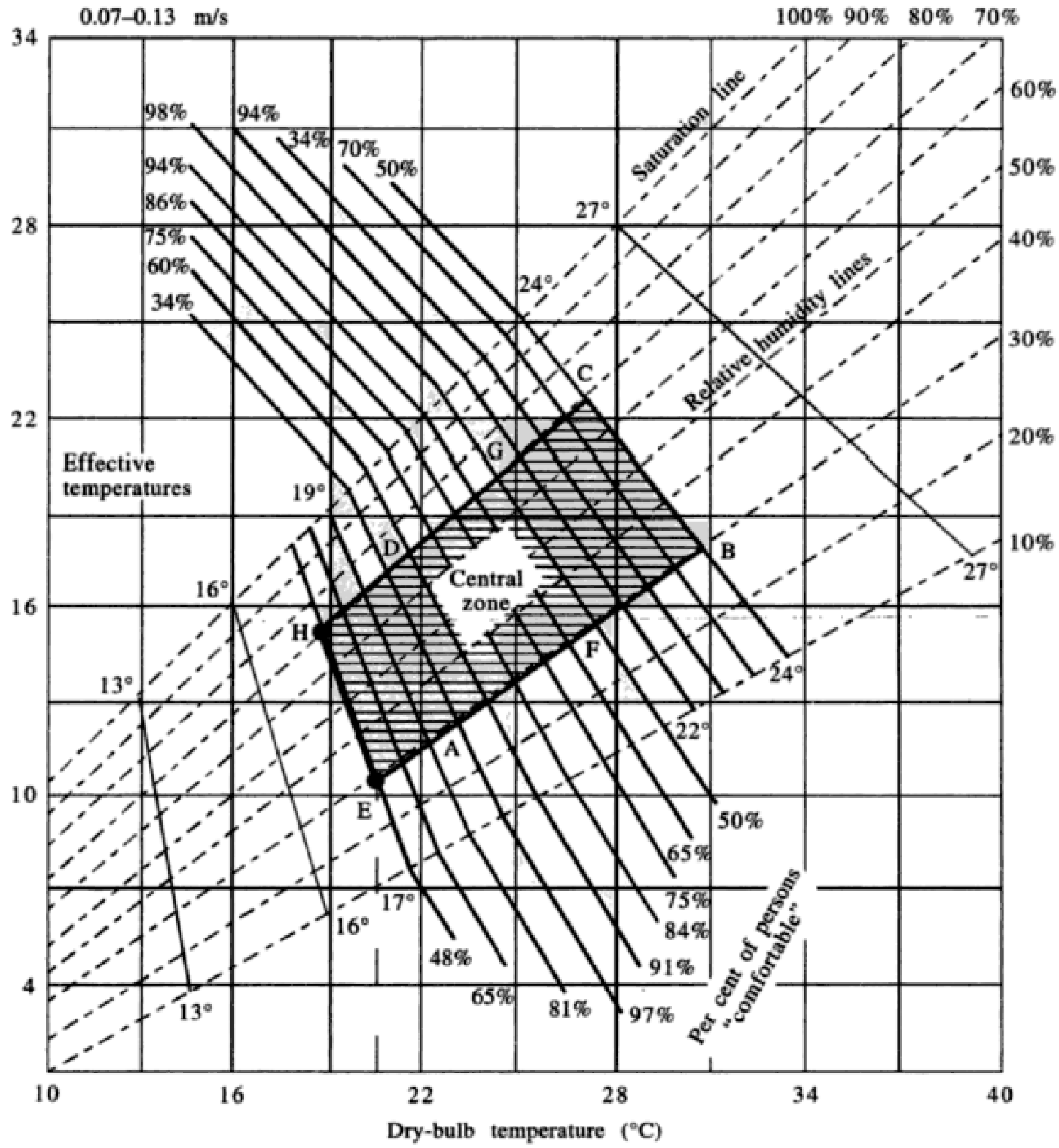

Figure 4 A typical comfort chart

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8. PREDICTION OF THERMAL COMFORT

The usual comfort parameters are ambient air temperature, humidity, air motion, body activity level, and clothing. However, it has been observed that if the surrounding surfaces are below the air dry bulb temperature, comfort would occur at a higher effective temperature than that indicated by Figure 4. This implies that radiant cooling affects comfort parameters/sensation appreciably. Studies have also indicated that women of all ages prefer an effective temperature about one degree higher than that preferred by men, while both men and women over 40 years age prefer an effective temperature about one degree higher than that desired by younger people. People of all climatic regions have identical preferred temperatures. The activity level of the occupants and the duration of occupancy also affect human thermal comfort sensation.

Thermal comfort and thermal sensation can be predicted by

(a) a comfort chart.

(b) numerically by the predicted mean vote (PMV) and the predicted percentage of dissatisfied (PPD).

The predicted mean vote predicts the mean response of a large group of people. This thermal comfort sensation scale as developed by Robles and Nevins is shown in Table 3.

TABLE 3 ASHRAE thermal sensation scale

+3	+2	+1	0	-1	-2	-3
Hot	warm	slightly warm	neutral	slightly cool	cool	cold

The test results have been correlated with the air dry-bulb temperature, humidity level, sex, and duration of exposure. The basic equation used to compute the PMV is:

$$PMV = a^{*}t + b^{*}p_{v} + c^{*} \qquad \textbf{(4)}$$

where, t is the dry bulb temperature and *Pv* is the corresponding saturation pressure, a*, *b** and*c** are the coefficients used for calculating PMV. The values of coefficients *a**, *b** and c*, can be obtained from Table 4.

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After calculating the PMV, the PPD is estimated for the same condition (Figure 5). The dissatisfied occupants are defined as those who do not vote either +1, 0 or -1 on the PMV scale.

The PMV-PPD model is widely used and accepted for design and field assessment of comfort conditions. It can be seen from the figure that even when the PMV is zero (i.e., no thermal load on the body) 5 % of the people are dissatisfied! When PMV is within ± 0.5, then PPD is less than 10.

TABLE 4: Coefficients *a**, *b** and *c** used to calculate the predicted mean vote (PMV).

Exposure period	**Sex**	**Coefficient** t(°C), Pv (kPa)		
		*a**	*b**	*c**
1.0	Male	0.220	0.233	-5.673
1.0	Female	0.272	0.248	-7.245
1.0	Combined	0.245	0.248	-6.475
3.0	Male	0.212	0.293	-5.949
3.0	Female	0.275	0.255	-8.622
3.0	Combined	0.243	0.278	-6.802

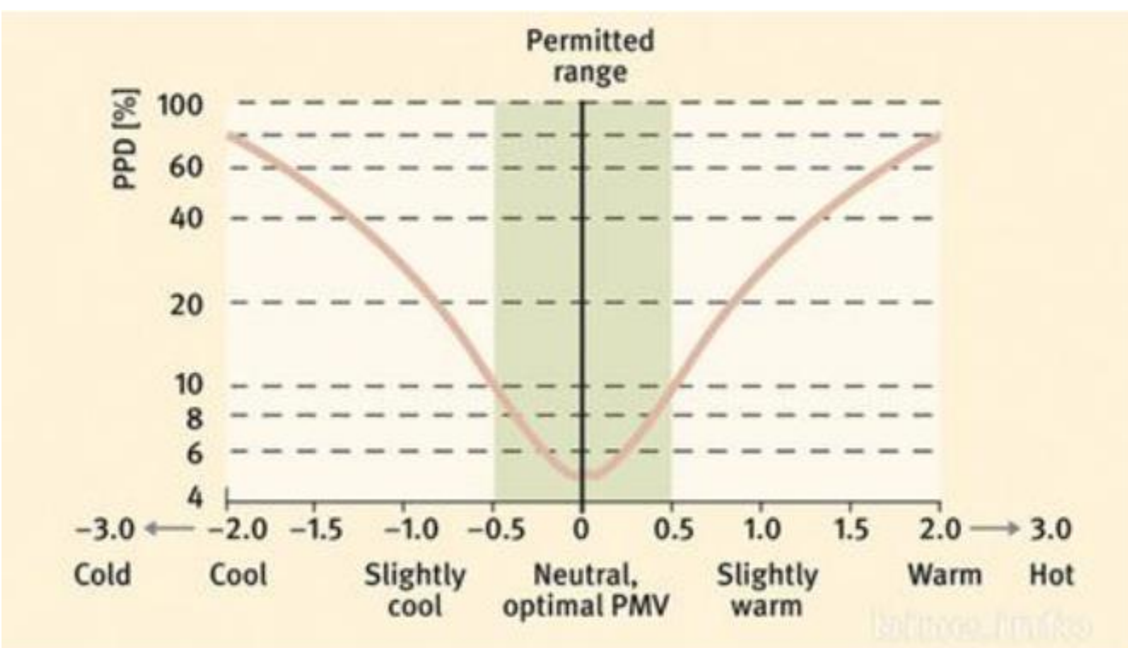

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Figure 5 Percentage of room users that are dissatisfied with the existing indoor environment conditions (PPD index – predicted percentage dissatisfied) as a function of the user's average subjective evaluation of the environment (PMV index – predicted mean vote) as suggested by Fanger.

Example 1

A number of male and female subjects took part in a climate chamber test. Determine the difference between the PMV of male and that of female occupants with the air dry bulb temperature being 24°C and the dew-point temperature being 20°C, 1 hour after entry into the space.

Solution

$$PMV = a^{*}t + b^{*}p_{v} + c^{*} \qquad (4)$$

PMV for men (using data from Table 3.4):

PMV = 0.22(24) + 0.233(2.339) - 5.673 = 0.051

Similarly, PMV for women:

PMV = 0.272(24) + 0.248(2.339) - 7.245 = -0.136

From the above, both males and females are predicted to be thermally neutral.

8.2 Outdoor design conditions for winter:

Similar to summer, it is not economical to design a winter air conditioning for the worst condition on record as this would give rise to very high heating capacities. Hence it is recommended that the outdoor design conditions for winter be chosen based on the values of **dry bulb temperature** that is **equaled or exceeded 99.6 or 99.0 % of total hours in a year.** Similar to summer design conditions, these values for major locations in the world are available in data books, such as AHRAE handbooks. Generally, the 99.0% value is adequate, but if the building is made of light-weight materials, poorly insulated or has considerable glass or space temperature is critical, then the 99.6% value is recommended.

Table .3.5 shows the ASHRAE recommended summer design conditions for some Iraqi cities.

Table 5: Outdoor design Conditions for Baghdad and Mosel.

Governor	Lat. o	Long. O	Winter DBT °C		Summer DBT °C			Summer WBT °C			Daily rang °C
			97.5%	99%	1%	2.5%	5%	1%	2.5%	5%	
Baghdad	33°20′N	44°24′E	1.5	0	42	44	45	22	22	23	19
Mosel	36°19′N	43°09′E	0	-1.5	43.5	44.5	45.5	22	22	23	22

9. Weather and climate

How does climate differ from weather?

9.1 Weather is the current atmospheric conditions, including temperature, rainfall, wind, and humidity at a given place. If you stand outside, you can see that it's raining or windy, or sunny or cloudy. You can tell how hot it is by taking a temperature reading. Weather is what's happening right now or is likely to happen tomorrow or in the very near future.

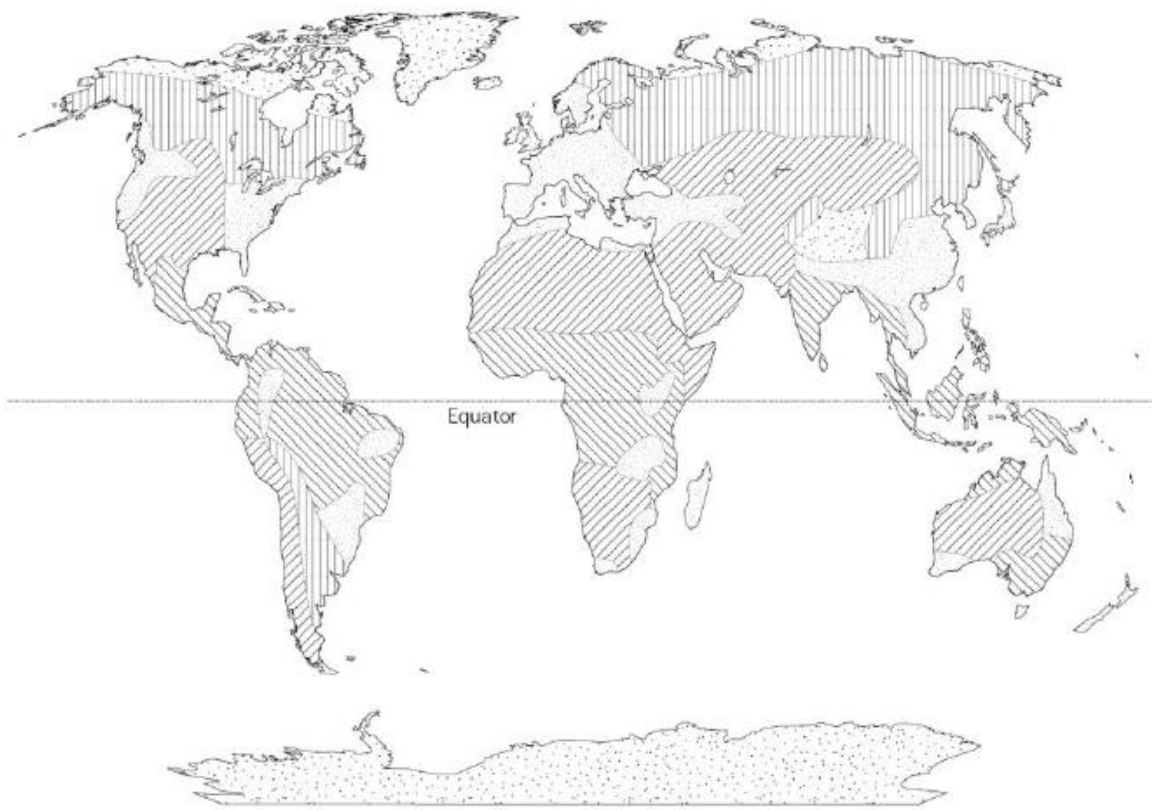
9.2 Climate, on the other hand, is the general weather conditions over a long period of time. Some meteorologists say that "climate is what you expect and weather is what you get."

According to one middle school student, "climate tells you what clothes to buy, but weather tells you what clothes to wear." Climate is sometimes referred to as "average" weather for a given area.

10. Classification of climates

The most classification of climate is the Koppen climate classification, that shown in figure 5 which classifies the world into six major groups of world climate, these groups are:

1- Cold and cool climates, 2- Warm temperature rain climate, 3- Hot dry climates (hot desert and steppe climates), 4- Composite climates, 5- Warm humid climates, and 6- Tropical upland climates.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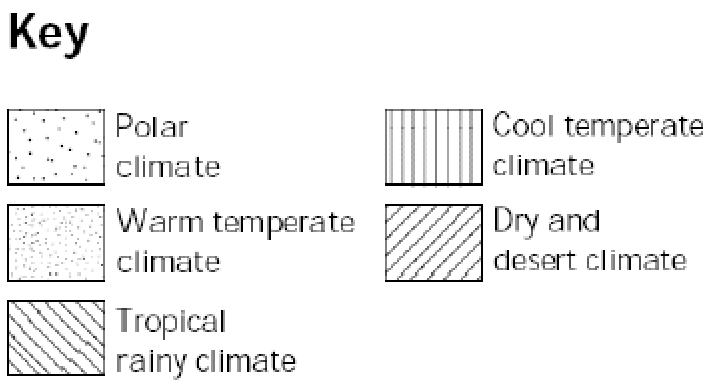

Figure 5 Koppen climate classification

11. Climate of Iraq:

11.1 Temperature.

The annual temperature rang in the arid desert is larger than in any other type of climate within tropic.

- The mean annual temperature of Baghdad is 23^{o}C,
- the mean temperature in August is 34 ^{o}C, and January is 10 ^{o}C.
- The mean temperature for summer season is 33 ^{o}C,
- while the maximum in July is 42 ^{o}C.
- The mean monthly number of days with maximum temperature equal or exceeding to 40^{o}C for Baghdad in August is equal to 30 day, and they are equal to 8 days when the maximums temperature equal to or exceeding 45^{o}C.

11.2 Sky Conditions and sun shine Iraqi climate is characterized by right sunshine, high solar radiation with very little could cover and radiation from the ground.

11.3 Relative humidity Baghdad has mean relative humidity of 30% in summer, and 65% in winter.

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