

STUDY OF SOME IMPORTANT CLIMATIC AND BIOCLIMATIC PARAMETERS OF KARACHI CITY CENTRE

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Climatic and bioclimatic studies of urban and suburban areas were made. Lasbella and Gurumandir were taken as urban areas and meteorological stations at the Karachi Airport and Mauripur were taken as the suburban areas. Air temperatures recorded at Gurumandir and Lasbella were higher as compared with those at the Airport and Mauripur. The range of temperature difference between Lasbella and the airport was 0.51 to 2.21° in the morning and the range of temperature difference between Gurumandir and the Airport was 0.32 to 1.03° in evening. Atmospheric relative humidities and wind velocities recorded at Lasbella and Gurumandir were lower than at the Airport and Mauripur. The range of relative humidity difference between Lasbella and Airport was 3 to 16.5% and the range of relative humidity difference between Gurumandir and Airport was 2 to 7.5%. The range of wind velocity difference between Gurumandir and the Airport was 3 to 10 knots and between Gurumandir and Mauripur 7 to 15 knots. Soil temperatures and light intensities of Lasbella and Gurumandir were also noted but no comparison could be made because of the unavailability of data for suburban areas. Light intensities recorded at Lasbella in the morning (9 a.m.) were greater than those recorded at Gurumandir (4 and 5 p.m.). On the other hand, soil temperatures of Gurumandir (4 and 5 p.m.) were higher as compared to Lasbella (9 a.m.).

INTRODUCTION

Rapid increase in urbanization is one of the major problems of mankind. People leave their land and rural environment and arrive in cities in an everwidening stream in search of jobs and a better life within the industrial city area. This rapid industrialization and urbanization is exerting a profound impacts on urban climate. For the first time, in the nineteenth century, Luke Howard [10] published the first edition of his work, the climate of London in which he compared the temperature of Somerset House and various sites beyond the urban fringe. Later in the 20th century many workers (2, 3, 13, 4, 21, 15, 14 and 17) studied urban climate in many parts of the world. According to Ayoade [1] these studies were mainly carried out in cities in the temperate region and comparable data for countries in the tropics are not available. However, only a brief study of the climate and microclimate of industrial area of subtropical Karachi, was made by Iqbal and Qadir (1974). In the present study the climate and the bioclimatic records of Karachi city centre were made and compared with the data available from the two meteorological stations situated away from the city centre.

Study sites: Karachi lies between 24°45' and 25°00' latitude and 66°55' and 67°15' longitude and is only 3 or 4 km from the Arabian Sea. The four localities from where the data were collected are elaborated herewith.

Lasbella and Gurumandir are approximately 9.5 km from the sea, densely populated and here comparatively less built-up areas. Heavy traffic densities on both these localities emit considerable amounts of oxides of nitrogen and mixtures of hydrocarbon. The Airport and Mauripur meteorological stations are located about 11 km and 4 km from the sea respectively. These two stations are less populated and have been built up areas as compared to Lasbella and Gurumandir. From the city centre, the Airport and Mauripur are on the eastern and western side respectively.

MATERIALS AND METHODS

Climatic and bioclimatic measurements of the city centre were made twice a week from 11th April to 30th May 1984. One measurement was made in the morning (9 a.m.) at Lasbella and the other two in the evening (4 and 5 p.m.) at Gurumandir. Air Temperature and relative

humidity were recorded at 1½ metre height from the ground surface by the cup anemometer (Karl Kolb Cat No. 529801). The units for wind velocity were converted into knots. Light intensity was noted by lux meter (Gossen 3.64 – 1404) at three different heights, (i) ground surface, (ii) (0.3) meter and (iii) 1.5 m from the ground surface. Soil temperature was measured by soil thermometer (Cat. No. 2012). The thermometer was inserted up to twenty centimeter depth.

RESULTS

Air temperature: Air temperatures, recorded at Lasbella at 9 a.m. and at Gurumandir at 4 and 5 p.m. were higher than those recorded at the Airport and Mauripur (Table 1–3). The range of temperature difference between Lasbella and the Airport was 0.51 to 2.21° and the range of temperature difference between Gurumandir and the Airport was 0.32 to 1.03° at 4 and 5 p.m. The range of temperature difference between Gurumandir and Mauripur was 0.66–2.66° at 5 p.m.

Air temperatures of Lasbella at 9 a.m. were lower as compared to the air temperatures of Gurumandir (Tables 1–3). The range of difference between Lasbella (9 a.m.) and

Gurumandir (4 p.m.) was 1.11 to 6.66°, whereas the range of temperature difference between Lasbella (9 a.m.) and Gurumandir (5 p.m.) was 0.55 to 2.78°.

Atmospheric relative humidity. Atmospheric relative humidities, recorded at Lasbella at 9 a.m. and at Gurumandir at 4 and 5 p.m. were lower than those recorded at the Airport and Mauripur (Table 1, 2, 3). The range of relative humidity difference between Lasbella and the Airport was 3 to 16.5% and the range of difference in relative humidity between Gurumandir and the Airport was 2 to 7.5% and 2.5 to 7.5% at 4 and 5 p.m. respectively. The range of difference between Gurumandir and Mauripur was 5.5 to 13% at 5 p.m. Relative humidities of Lasbella at 9 a.m. were higher as compared to the relative humidities of Gurumandir at 4 and 5 p.m. (Table 1, 2, 3). The range of difference between Lasbella and Gurumandir was 2 to 27%. Only one reading at Gurumandir at 4 p.m. and two readings at Gurumandir at 5 p.m. were higher than those at Lasbella and the range of difference was 1.5 – 7.5%.

Wind velocity: Wind velocities, recorded at Lasbella at 9 a.m. demonstrated that out of 15 readings, 3 readings were higher as compared to the Airport and the range of difference was 0.4 to 1.1 knots (Table 1). Eleven readings

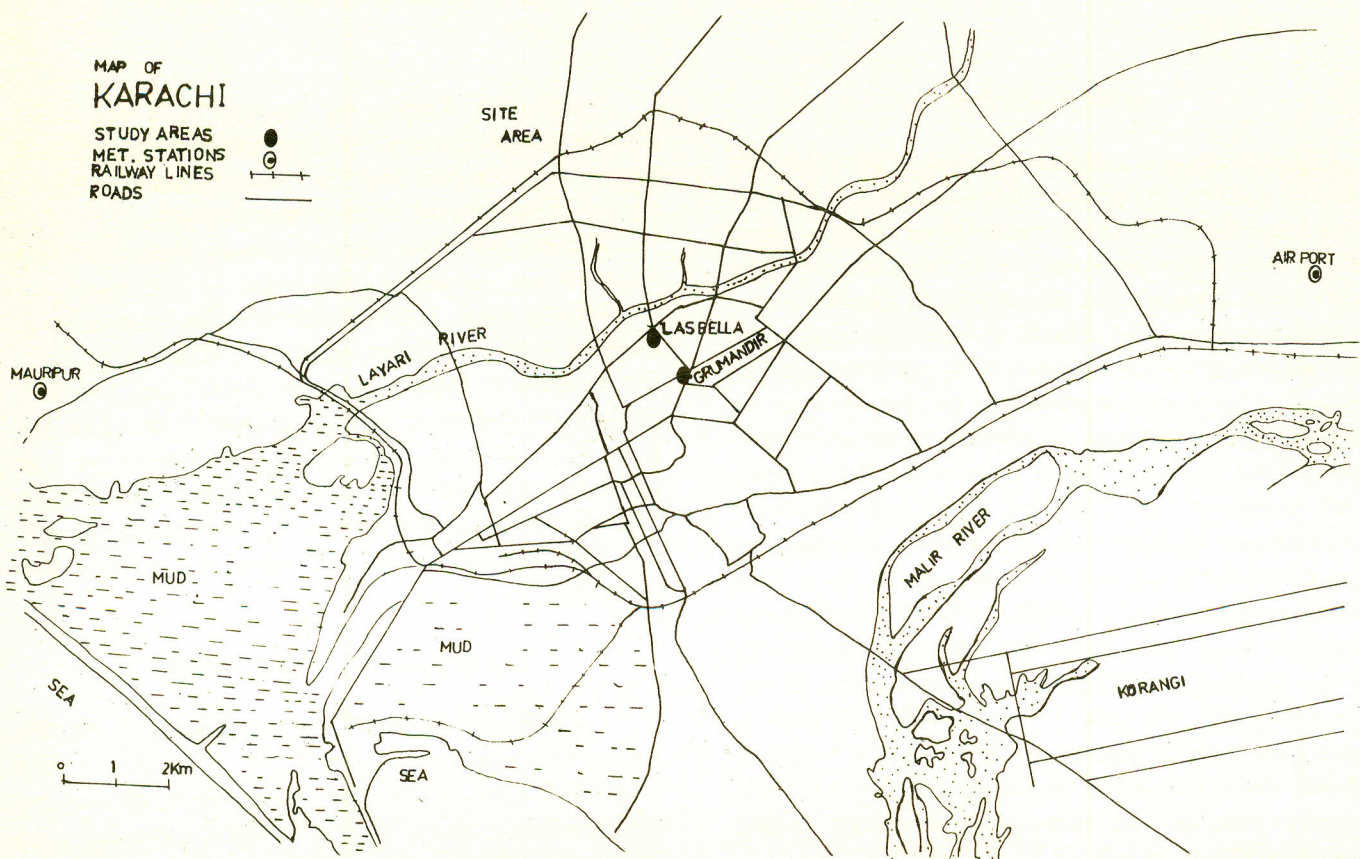


Table 1. Comparative study of atmospheric temperature, atmospheric relative humidity, and wind velocity at Lasbella and Airport (Time: 9.00 a.m.)

Dates	Temperature (°C)		Temperature difference (a-b)	Relative humidity (%)		R. humidity difference (a-b)	Wind velocity (Knot)		Velocity difference (a-b)
	Lasbella (a)	Airport (b)		Lasbella (a)	Airport (b)		Lasbella (a)	Airport (b)	
11-4-84	31.11	28.9	+2.21	41.0	57.5	-16.5	01	02	-1
14-4-84	30.00	28.5	+1.50	69.0	77.5	- 8.5	03	03	0
18-4-84	31.66	30.0	+1.66	47.7	61.5	-13.8	03	05.6	-2.6
21-4-84	32.22	30.75	+1.47	39.0	43.5	- 4.5	02	04.6	-2.6
25-4-84	30.00	28.75	+1.25	65.0	71.0	- 6.0	02	03.7	-1.7
28-4-84	31.66	29.80	+1.86	59.5	67.5	- 8.5	03	05.6	-2.6
2-5-84	28.88	27.50	+1.38	57.0	68.5	-11.5	03	02.3	+0.7
5-5-84	30.55	29.25	+1.30	58.0	71.5	-13.0	04	07.9	-3.9
9-5-84	31.66	31.00	+0.60	63.0	71.0	- 8.0	04	03.6	+0.4
12-5-84	31.11	30.25	+0.86	73.0	76.0	- 3.0	04	08.3	-4.3
16-5-85	31.66	30.50	+1.16	69.5	75.0	- 5.5	02	00.9	+ 1.1
19-5-84	30.00	29.00	+1.00	66.5	76.0	- 9.5	03	09.0	- 6
23-5-84	30.55	29.25	+1.30	68.0	77.0	- 9.0	04	09.0	-5
26-5-84	32.22	31.25	+0.97	60.0	71.5	-11.5	05	08.6	-3.6
30-5-84	31.11	30.60	+0.51	59.0	64.0	- 5.0	06	10.0	-4

Table 2. Comparative study of air temperature, atmospheric relative humidity and wind velocity at Gurumandir and Airport. (Time: 4.00 p.m.)

Dates	Temperature (°C)		Temperature difference (a-b)	Relative humidity (%)		Relative humidity difference	Wind velocity (Knot)		Velocity difference (a-b)
	Gurumandir (a)	Airport (b)		Gurumandir	Airport		Gurumandir	Airport	
11-4-84	37.77	37.25	+0.52	14.0	20.5	- 6.5	03	05.0	- 2
14-4-84	32.22	31.80	+0.42	57.0	62.5	- 5.5	04	06.4	- 2.4
18-4-84	34.44	34.00	+0.44	53.0	60.5	- 7.5	04	09.0	- 5
21-4-84	37.22	36.75	+0.47	17.0	21.0	- 4.0	04	07.6	- 3.6
25-4-84	33.33	32.33	+1.00	52.0	59.5	- 6.5	03	07.0	- 4.0
28-4-84	34.44	33.70	+0.74	36.0	41.5	- 5.5	04	07.6	- 3.6
2-5-84	32.22	31.30	+0.92	54.0	58.0	- 4.0	04	07.6	- 3.6
5-5-84	32.22	31.60	+0.62	57.0	64.0	- 7.0	05	10.0	- 5.0
9-5-84	33.89	33.30	+0.59	58.5	60.5	- 2.0	05	09.6	- 4.6
12-5-84	34.44	33.75	+0.69	59.0	64.0	- 5.0	05	09.0	- 4.0
16-5-84	35.33	34.30	+1.03	54.0	58.0	- 4.0	03	06.3	- 3.3
19-5-84	33.33	32.75	+0.58	58.0	61.5	- 3.5	04	09.4	- 5.4
23-5-84	33.33	32.75	+0.58	61.0	64.0	- 3.0	07	12.0	- 5.0
26-5-84	35.00	34.25	+0.75	53.5	56.5	- 3.0	05	13.33	- 8.33
30-5-84	32.22	31.90	+0.32	57.0	63.0	- 6.0	08	15.33	7.33

demonstrated that the wind velocities at the Airport were higher than those recorded at Lasbella and the range of difference was 1 to 6 knots. At Gurumandir all 15 readings of wind velocities were lower than those recorded at the

Airport and Mauripur. The range of wind velocity difference between Gurumandir and Airport were 2 to 8.33 knots and 3 to 10 knots at 4 p.m. and 5 p.m. respectively. The range of difference between Gurumandir and Mauripur

was 8 to 14 knots. The wind velocities recorded at Gurumandir in the evening were higher as compared to Lasbella in the morning hours (Tables 1, 2, 3). The range of difference between Lasbella (9 a.m.) and Gurumandir (4 p.m.) was 0 to 3 knots and the range of difference between Lasbella (9 a.m.) and Gurumandir (5 p.m) was 0 to 2 knots.

Light intensity: Light intensities recorded at Lasbella in the morning (9 a.m) were higher than those recorded at Gurumandir in the evening hours (4 and 5 p.m) (Table 4). The range of light intensity difference between Lasbella (9 a.m) and Gurumandir (4 p.m) was 0 to 60 lux, and the range of difference between Lasbella (9 a.m) and Guruma-

ndir (5 p.m) was 40 to 81 lux. Maximum light intensity (185 lux) was recorded in the morning (9 a.m) on 28th April 1984, whereas the minimum light intensity (66 lux) was noted in the evening (5 p.m) on the 16th May 1984.

Soil temperature. Soil temperatures recorded at Gurumandir in the evening were higher than those recorded at Lasbella in the morning (Table 4). The range of difference between Lasbella (9 a.m) and Gurumandir (4 p.m) was 6.5 to 11°. The maximum soil temperature (46°) was measured at Gurumandir in the evening (4 p.m) on 14th April 1984 and the minimum soil temperature (34°) was noted in the morning of the 11th April and 28th April 1984.

Table 3 (A). Comparative study of air temperature, relative humidity and wind velocity at Gurumandir, Airport and Mauripur (Time: 5.00 p.m.)

Dates	Temperature (°C)			Temperature difference b/w Gurumandir and Airport	Temperature difference b/w Gurumandir and Mauripur	Relative humidity (%)			Humidity difference b/w Gurumandir and Airport	Humidity difference b/w Gurumandir and Mauripur
	Gurumandir	Airport	Mauripur			Gurumandir	Airport	Mauripur		
2-5-84	31.66	31	29	+0.66	+2.66	53.5	60	65	- 6.5	- 11.5
5-5-84	31.66	31	30	+0.66	+1.66	59.5	66	72	- 6.5	- 12.5
9-5-84	33.33	33	32.5	+0.33	+0.83	58.0	61	64	- 3.0	- 6.5
12-5-84	33.61	33	32	+0.61	+1.61	60.0	65	70	- 5.0	- 10.0
16-5-84	33.33	33	32	+0.33	+1.33	52.0	57	61	- 5.0	- 9.0
19-5-84	32.77	32	31	+0.77	+1.77	59.5	67	66	- 7.5	- 6.5
23-5-84	32.77	32	31	+0.77	+1.77	62.0	67	75	- 5.0	- 13.0
26-5-84	34.44	34	33	+0.44	+1.44	53.0	57	59	- 4.0	- 6.0
30-5-84	31.66	31	31	+0.66	+0.66	66.5	69	72	- 2.5	- 5.5

Table 3 (B) Comparative study of air temperature relative humidity and wind velocity at Gurumandir Airport and Mauripur (Time: 5.00 p.m.)

Date	Wind velocity (Knot)			Velocity difference b/w Gurumandir and Airport (a-b)	Velocity difference b/w Gurumandir and Mauripur (a-c)
	Gurumandir (a)	Airport (b)	Mauripur (c)		
2-5-84	04	SW 09	SW 12	- 5	- 8
5-5-84	04	SW 10	SW 16	- 6	- 12
9-5-84	05	SW 10	SW 19	- 5	- 14
12-5-84	05	SW 10	SW 16	- 5	- 11
16-5-84	03	SW 07	SW 12	- 4	- 9
19-5-84	04	SW 09	SW 16	- 5	- 12
23-5-84	05	SW 12	SW 16	- 7	- 11
26-5-84	04	SW 10	SW 14	- 6	- 10
30-5-84	08	W 16	SW 21	- 8	- 13

Table 4. Light intensity and soil temperature at Lasbella and Gurumandir
 Light intensity (Lux) Soil temperature (°C)

Dates	Lasbella						Gurumandir											
	9 a.m.			4 p.m.			5 p.m.			9 a.m.			4 p.m.			5 p.m.		
	Ground	0.3 m	1.5 m	Ground	0.3 m	1.5 m	Ground	0.3 m	1.5 m	Ground	0.3 m	1.5 m	Ground	0.3 m	1.5 m	Ground	0.3 m	1.5 m
11.4.84	120	125	130	115	115	115	—	—	—	34.0	45.0	—						
14.4.84	140	135	135	125	125	125	—	—	—	35.25	46.0	—						
18.4.84	135	140	140	125	130	125	—	—	—	35.0	45.0	—						
21.4.84	140	140	140	130	135	135	—	—	—	35.5	44.0	—						
25.4.84	145	145	150	140	140	145	—	—	—	35.0	42.5	—						
28.4.84	180	185	185	120	125	130	—	—	—	34.0	44.0	—						
2.5.84	130	135	140	125	130	135	90	92	92	35.0	44.0	43.5						
5.5.84	135	135	140	125	125	125	90	90	95	35.5	44.5	44.0						
9.5.84	140	140	145	120	125	125	80	85	85	35.5	43.0	42.5						
12.5.84	140*	140*	145*	130	135	135	85	85	90	36.0	43.0	42.5						
16.5.84	130	135	135	122	122	125	66	70	70	35.5	43.5	43.0						
19.5.84	143	139	140	125	125	130	70	74	75	36.0	44.0	43.5						
23.5.84	170*	165*	165*	120	125	125	89	90	91	36.0	43.0	42.5						
26.5.84	165	170	170	160	165	165	90	92	92	36.0	43.5	43.5						
30.5.84	130*	135*	130*	125	125	130	90	89	89	35.5	43.0	41.5						

* The numbers varied due to clouds. The mentioned numbers were the maxima.

DISCUSSION

Air temperatures, recorded at Lasbella in the morning and at Gurumandir in the afternoon were higher as compared at the Airport and Mauripur meteorological stations. There are many factors such as automobile combustion, city fabric, less evaporation and transpiration surfaces, wind velocity, location of population that influence the temperature of the area. Among these automobile combustion is probably one of the major factors which is responsible for increase in the temperature. Climatic and bioclimatic measurements at Lasbella on the Business Recorder Road and at Gurumandir on the M.A. Jinnah Road, were recorded in the morning and afternoon respectively. At both these points the traffic densities were at its peak which contribute excessive exhausts from diesel engines which contains various oxides of nitrogen and from petrol containing various mixtures of hydrocarbons. These pollutants cut down the incoming short wave radiation and do not allow the long wave radiation to escape to space with the result of these changes in the heat balance, cities tend to be warmer than the surrounding rural areas [16].

City fabric is the second important factor that influences the air temperature of Lasbella and Gurumandir. Build-

ings, pavements and roads absorb and store radiation during the day and gradually release it into the atmosphere at night [1]. Bitumen roads of Lasbella and Gurumandir have low albedo. According to Griffiths [7] black top roads absorb 90-95% of incoming radiation whereas only 70-75% of the incoming radiation is absorbed by deserts (Karachi is a semi desert area). As far as buildings are concerned, Lasbella and Gurumandir are not much built up areas. However, there are three and five storeyed flats which cause the storage of heat. Sunlight penetrates through the windows into the buildings where since, the surfaces are dry, all the radiation is stored as sensible heat in construction materials [1]. This stored heat is released slowly throughout the 24 hr. period and warms the atmosphere. Some trees on the roadside at Lasbella and a small KMC park at Gurumandir indicate that not much energy is used for evapotranspiration process but most of the energy is used for warming up the air.

According to many workers [2, 18, 7, 1] wind velocity is the most important factor which can eliminate or dislocate the urban heat island phenomenon. Although air temperature as a result of automobile combustion was

greater at M.A. Jinnah Road (55,002 vehicles/day) as compared to the Business Recorder Road (26,288 Vehicles/day; Traffic Engineering Bureau, KDA, 1982), yet the temperature difference between Lasbella and the Airport was greater than those between Gurumandir and the Airport. The main reason was the high wind velocity in the afternoon as compared to the morning hours. Moreover, maximum air temperature difference was recorded between the Airport and Lasbella when there was minimum wind velocity and almost no air temperature difference was recorded when the wind velocity was maximum, i.e., 16 knots at the Airport. Therefore, it is possible that the heat island of Karachi could be destroyed by a wind velocity of more than 16 knots. A comparison among the air temperatures of Gurumandir, the Airport, and Mauripur indicates that the heat island which started forming in the morning as shown by the heat island of Lasbella moved towards the northeast due to greater velocity of westerly and south westerly winds. Although the distance between the study areas and the two meteorological stations (Airport and Mauripur) are almost equal, there was a great difference in temperature between the study sites and Mauripur than between the study sites and the Airport. The Mauripur meteorological station is located on the western side of city centre. Therefore, it is not affected by pollutants. The industrial area of Shershah is present three miles away from Lasbella and Gurumandir in the westward direction. Most of their pollutants moved in easterly direction, absorb radiation, which resulted, the increase of temperature of the area. Moreover, Lasbella and Gurumandir are densely populated areas, therefore, human metabolism increase the temperature [1] of the surroundings area. However according to many workers [2, 9, 11]; the intensity of heat island is not necessarily related to city growth.

Atmospheric relative humidity recorded at Lasbella and Gurumandir was lower than that recorded at the Airport and Mauripur. This might be due to the removal of the surface runoff by urban sewerage system, lack of extensive vegetation cover and absence of swamps or water pool from which evapotranspiration could take place [1]. The range of relative humidity difference between Lasbella and the Airport was greater than those between Gurumandir and the Airport. This could be due to the presence of a small KMC Park immediately on the eastern side of Gurumandir. Secondly, Gurumandir is quite open area, whereas the Business Recorder Road at Lasbella acts like a small valley in which air movement does not take place freely because of its surroundings. The Business Recorder Road is lying as south-east north-west. Water vapour from smoke chambers of many industries (Iqbal and Qadir, 1974) flow over Las-

bella and Gurumandir and therefore, could not reach the ground. The presence of low watervapour at Gurumandir and Lasbella could decrease the moisture content of the area to some extent. Light intensities, recorded at Lasbella and Gurumandir at three different heights, did not show any marked difference (Table 4). This might be due to the absence of any barrier to show any marked difference of incoming radiation at these heights. Due to unavailability of data from the meteorological stations, no comparison could be made between the light intensities of urban and suburban areas.

Similarly, no comparison between the soil temperatures of urban and suburban areas could be possible because of the reason mentioned above. However, the soil temperatures, recorded at Gurumandir in the evening hours were much greater than those recorded at Lasbella in the morning. There are two factors which were responsible for the increase of temperature at Gurumandir. Firstly, air temperatures at Gurumandir was much greater as compared to Lasbella. Secondly the soil of Gurumandir was dry and sandy whereas the soil of Lasbella was comparatively wet and somewhat silty. According to Griffiths [7] dry and sandy soil heat up very rapidly as compared to wet and silty soil.

CONCLUSION

In the future development plans a few items stand out as being worthy of note.

(1) The construction of multi-storeyed buildings should be avoided. Orientation of the buildings and the width of streets should be chosen to maximise wind velocity. Streets may be arranged to enhance the inland penetration of the sea breeze [8]. There should be more public open spaces between the buildings to avoid high temperature.

(2) Plantation should be increased along the roadsides and on public open spaces. Trees help to moderate the urban heat island effect since more energy will be utilized for evapotranspiration and less will be available to heat the air [1].

(3) Industries should not be installed on the western side of the city. Winds carrying pollutants from the industries of the SITE areas, Shershah and particularly from Javidan Cement Works and Valika Chemical Industries are affecting the main suburbs of Karachi.

(4) New township scheme should be planned on the western side of the city to avoid industrial and automobile pollution.

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