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Temperature fields of Pune city

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An attempt has been made to analyse the temperature fields in Pune city by adopting a technique of mobile temperature survey. One major heat island, and three secondary heat pockets have been identified. Cool pools have been located in the western hilly sector of the city. The highest minimum temperature of 14.3°C was recorded in the city core, while the lowest temperature of 5.8°C was near Pashan lake.

DESPITE rapid urbanization in low latitudes, there is a greater imbalance between mid and low-latitude knowledge of urban climates and its application. Unplanned and unabated urbanization in most tropical cities has led to formidable environmental problems. These problems could be minimized if climatological experiences and principles are incorporated in the planning process. One of the major expressions of the adverse effects of urbanization and industrialization is the formation of heat islands. This aspect has formed the major research theme in urban climatology in the last few years. The existence of the urban heat island can be linked to various factors. A city surface, mixture of vertical and horizontal elements creating urban canyons, is responsible for lowering of the albedo[1,2]. Other factors include the addition of heat by combustion processes, the metabolism of living beings and reduction of wind speed. But the most important factor seems to be the change in radiative balance within the urban areas[3]. Though the meteorological consequences of urbanization have been noted since early times, detailed descriptions have been reported only in the last few decades[4-6]. In India, such studies have been conducted for large metropolitan cities like Delhi, Bombay and Pune[7-10]. A mobile temperature survey conducted in late 1970s in Delhi revealed that the city core is warmer by 5°C in December and by 7°C in January than the rural countryside[7]. The first heat island study of Pune city conducted in 1978 indicated the presence of two warm pockets, one over the city core and the other over the industrial area in the northern sector[10].

In recent decades, Pune city has witnessed a phenomenal growth in its population and vehicular traffic. As a consequence, the built-up area of the city has increased disproportionately and the climate of the city has been adversely affected. This has motivated the present authors to undertake the study of the temperature fields in the city.

Pune is one of the largest metropolitan cities in Western India supporting about 1.8 million persons and continuously expanding. The city (18°3'N and 73°5'E), situated on the western margin of the Deccan Plateau, lies on the leeward side of the Western Ghats. The town is surrounded by hillranges in the north, south and west. In the north, the area is marked by gentle slopes and the altitude is below 650 m ASL. The present ecological structure of Pune bears the heavy imprint of the city's historical past characterized by limited industrialization and slow economic growth. Pune developed in five stages and these are appropriately represented by five sectors in this study. The hilly sector has also been

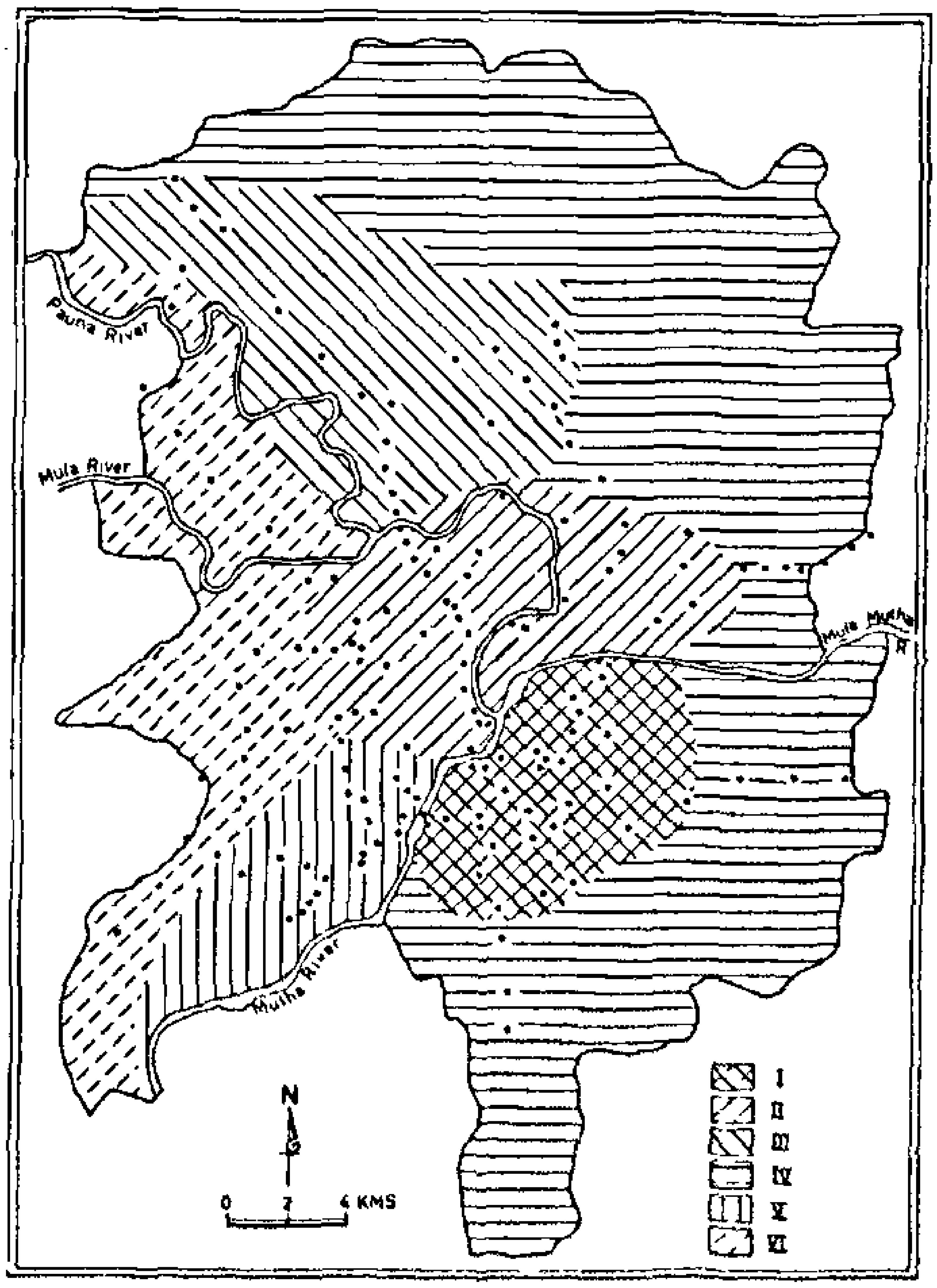

Figure 1. Sectors and survey sites of Pune city I Old core II Initial extension, III, Industrial region, IV, Development after the Panshet disaster, V, Rapidly developing extension, VI, Hilly region

included, since the drainage of cold air affects the temperature distribution (Figure 1).

The climate of Pune, although tropical in general, is often marked by departure from the normal. Owing to its position in the shadow behind the Ghats, the climate of the city is dry during most of the year. On account of its elevation and dryness, Pune is relatively cool during the nights even in summer. During the cool season, Pune is subjected to a high frequency of anticyclonic conditions that give rise to almost cloudless nights and abundant sunshine during the day. In this period, dry northeasterly land winds prevail during most of the day.

Since the heat island effect is most pronounced around the minimum temperature epoch, when light winds and poor dispersion conditions prevail, the survey was conducted in winter on 3 January 1993 between 0200 and 0600 hrs IST. To study the horizontal variation in temperature, a mobile survey method was adopted following the standard procedure given by WMO[11] and the temperatures were recorded at various times and locations.

Ten routes radiating from the central meteorological observatory were devised, covering more than 150 survey sites (Figure 1). Along each route, an outward and a return leg of the traverse was conducted and readings taken at the predetermined sites (at an interval of 2–3 km). In the city core, a dense network of observation points was devised. To check the variations in temperature are linear, nine thermographs were placed along each traverse route. At each site, readings of dry bulb thermometers were taken using a calibrated whirling psychrometer and the time of observation noted using synchronized watches. The temperature distribution as corrected and reduced to 0300 h is presented in Figure 2.

Figure 2 illustrates that the intense heat island (H1) is located over the core part of the city, bounded by Mula-Mutha rivers in the north. The temperature in this area is above 14°C, with the highest recorded temperature of 14.3°C at the K.E.M. hospital. This portion of the old core has numerous buildings dating from the colonial period. Since then, it has been densely populated. The structural plan of this area is highly congested with closely packed buildings. During the last decade, an increase in rebuilding took place in the city centre with tower blocks and limited open spaces. In addition, the area being a part of the central business district of Pune, experiences heat island effect. It is important to note that the main vegetable market and its surrounding areas, identified as a centre of heat island in the 1978 survey[10] lies on the periphery of the heat island in the present study. This may be on account of the demolition of two cinema theatres leading to more open space available for free air circulation.

Three secondary pockets having temperature above 13°C have been identified, viz. H2, H3 and H4 (Figure 2). In the last decade, the area around H2 (Alka

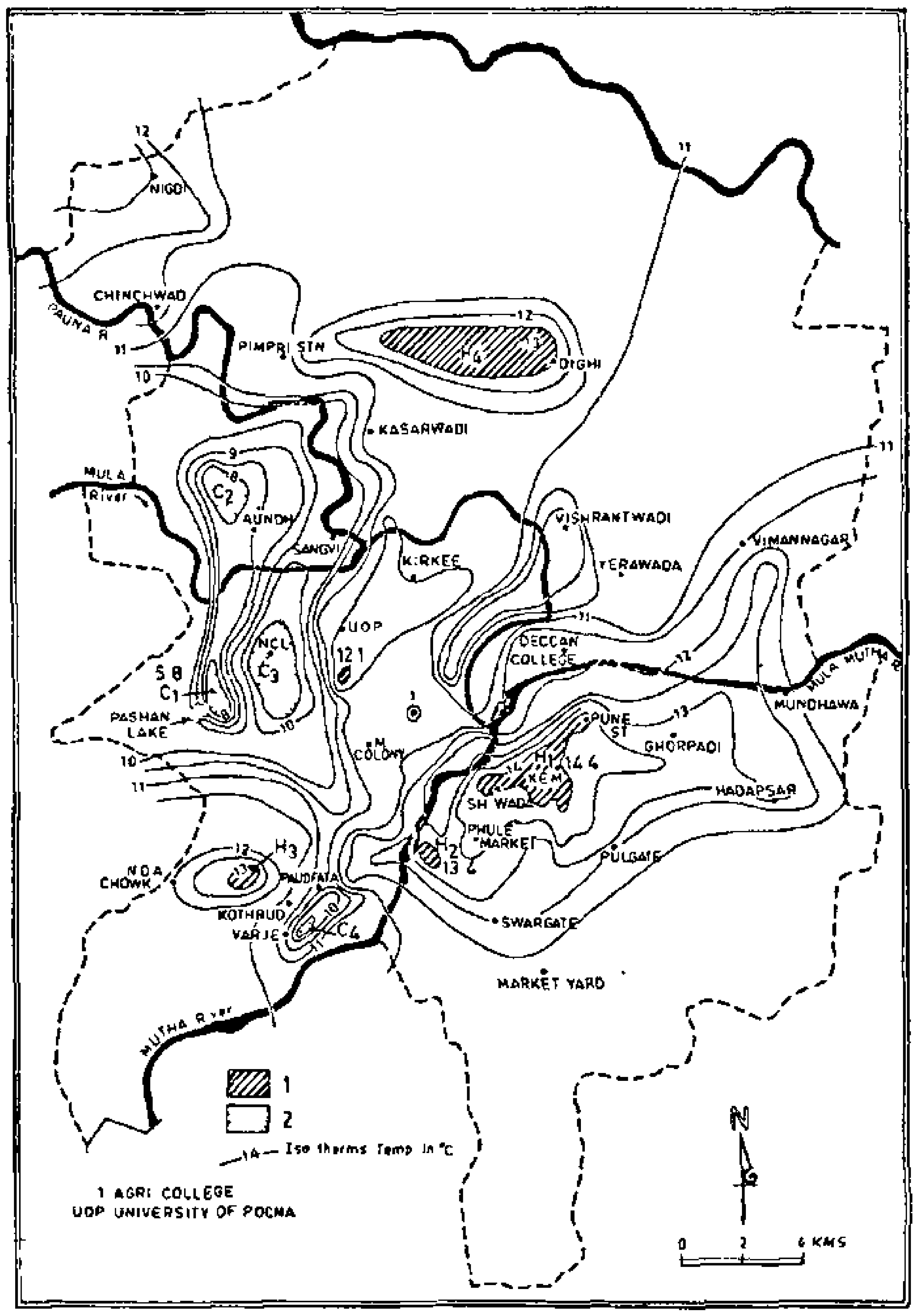

Figure 2. Heat islands and cool pools in Pune city H1, City core, H2, Alka talkies, H3, Kothrud, H4, Pimpri-Dighi, C1, Pashan lake, C2, Aundh, C3, National Chemical Laboratory, C4, Warje; 1, Warm pockets, 2, Cool pools

Talkies) has undergone a rapid construction phase, and has emerged as a major commercial complex. Old medium-sized buildings are being replaced by multi-storeyed structures with marginal road widening. This might have adversely modified the micro-meteorological environment of the area, resulting in the formation of a warm pocket.

The H3 area (Kothrud) in the southwestern sector, is the fastest developing extension of the city. The unplanned and compact growth of this sector may have resulted in the formation of a warm pocket. It should be noted that these newly developed warm pockets (H2 and H3) were not reported earlier[10].

The industrial and the subsequent residential growth in the northern sector of the city primarily occurred during the post-independence period. Urban sprawl over the adjoining areas in recent years has resulted in the formation of a heat island (H4). This island extends between river Pauna in the west and the Dighi hills to the east.

Interestingly, cool pools have developed over the western sector of the city, due to the favourable topographic setting of the area. The area is bounded by hill ranges (> 700 m ASL) on the western margin and by Pauna and Mutha rivers to the north and south respectively. Drainage of cold air from these hill ranges might have been responsible for the formation of cool pools in the foothill zone. The lowest minimum temperature of 5.8°C was recorded near Pashan lake (C1) located in a natural depression surrounded by hills. At this site, the relative relief is more than 100 m and this might have resulted in stagnation of cold air leading to lower temperature. The other cool pools namely C2, C3 and C4 were observed near Aundh and N.C.L. in the western sector, and at Warje in the southwestern sector respectively. In comparison with other cool pockets, C1 exhibits remarkably low temperature values. This difference can be possibly attributed to the lower relative relief in the vicinity of other cool pocket sites. In view of the above discussion the occurrence of H3 pocket in the west is anomalous. This can be attributed to the overwhelming effect of the process of intense urbanization over the effect of terrain characteristics on the formation of temperature fields.

The preceding discussion leads one to conclude that urban influences on the temperature distribution within Pune city are very pronounced. It is well-reflected in the rapid cooling at the outskirts than in the built-up areas in the city. The major heat island was observed over the densely populated old core of the city where the magnitude of temperature difference is about 3.5°C. It is interesting to note that the centre of heat island identified in 1978 has shifted towards northeast. The study further demonstrates that the industrial area to the north continues to be a warm pocket. The development of two additional warm pockets (H2, H3) can be associated with rapid urbanization, in the last decade. Three cool pools detected during the survey owe their existence to the hilly terrain in the western sector. The lowest temperature of 5.8°C, as expected, was observed near Pashan lake. The anomalously high temperature giving rise to the heat pocket (H3) can be explained in terms of the overwhelming influence of development over topography in the Kothrud area.

In this context, it can be suggested that to reduce the intensity and adverse effects of heat islands, the planning of urban complexes should include green parks and open spaces. Such green pockets are not only important as recreational areas but will also contribute in amelioration of the undesirable features of city climate.

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Diurnal and seasonal variations in air pollutant concentrations in a seasonally dry tropical urban environment

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Air quality monitoring of Varanasi city indicates a logarithmic normal distribution pattern of 2-h mean concentrations of SO_2, NO_2 and O_3. Ozone concentrations peaked from late morning to afternoon of summer and those of SO_2 and NO_2 during early morning and late evening of winter months. The coincidence in the timing of SO_2 and NO_2 peaks appears interesting from the biological perspectives.

AIR quality monitoring is important for understanding the air pollution effects on living systems. Air quality data have been used to establish relationships between pollutants[1], between source and sink[2] and between plant and pollutants[3]. Recent studies have emphasized the importance of peak exposure in eliciting adverse effects on plants[4,5]. Peak concentration of SO_2 affects vegetation more adversely than prolonged exposure to low concentrations[6,7]. Further, the combination of SO_2 and NO_2 has been shown to cause visible injury at considerably lower concentrations than those required for either gas alone[8]. Thus data regarding peak concen-