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Impact of Topography on Temporal and Spatial Characteristics of Air Temperature in Aligarh City, Uttar Pradesh, India

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Abstract: ***The topographical variation is inherent property of the land, modifying the macroclimatic conditions and important to select the site for habitation. Relationships have been determined between topographic variation and micro-climatic conditions in Aligarh city that resembles to numbers of city in North India. For determining this relationship daily minimum and maximum air temperature were recorded at different altitude and locations in Aligarh city for the period between Februarys to May, 2020. The results indicated that the elevated part of city experience slightly warm and cool in winter and summer respectively compare to vast lesser elevated part of city. These moderated climatic conditions compare to surrounding resulted in development of medieval cities in recent past in many civilizations.***

Keywords: Topography, Urban meteorology, Macroclimate, Climate

1. Introduction

About 33% of total population of India is currently living in urban areas, which is projected to reach 50% by 2050 [1]. To fulfil the requirement of urban spaces the developmental authorities adding heavy infrastructure in the existing city. The resulted rapid change in infrastructure, residential, commercial and other development in urban conglomeration influencing micro climatic conditions. Along with new infra-structure development local topography and climate are also intertwined that influence the local micro-climatic condition. The local topography includes the physical features of the land's surface, including elevation, slope, and landforms. City planners, architects, and urban designers to consider the interplay between topography and climate when designing and developing urban areas. Factors such as topography, vegetation, and urban development influences the broader climatic conditions and forms the microclimatic zones within a city. Planning also has a significant impact on the creation and modification of microclimates within urban areas. It influences the temperature variation with city, air quality, wind flow and thermal comfort, rainfall flooding, building energy efficiency, vegetation and biodiversity and public spaces Micro-climate range from one to several kilometers [2], [3], [4]. In the lower atmosphere, thermal structure is linked to daily cycle of solar radiation, as matter and heat energy exchanges between the surface and the air are very significant. Land altitude, orientation, slope system and influence the hours of sunshine and temperature variability which are essential factors to explain micro climates [5], [6], [7]. The rapid growing center of urbanization are also associated with a large change in quality of local land use /land cover, biodiversity, hydrology, atmosphere, climate [8]. It is resulting in raising the atmospheric temperature of the urbanized area corresponding to neighbor rural areas of the city. Higher temperature in urban areas increases the demand for air conditioners, raises the pollution levels, increases dryness and also modifies the natural cycle of precipitation [9]. As a result, studies of spatial distribution of climatic characteristics become important for the requirement of sustainable planning and environmental protection of cities [10], [11].

In present study the influence of topography on air temperature has been studied in Aligarh city. The terrain characteristics of this city resembles with other many cities in Indo-Gangetic area of India. It is characterized by small big hillock in vast plain terrain. This study was conducted in special time during COVID-19 lockdown period and provide an opportunity to interpret the city temperature with reference to topography.

2. Area of study

The city is located in the plains between the Ganga and Yamuna rivers (Fig. 1). It is nearly a level plain and slight elevation is the centre. Southern part of the city has old habitation and new urbanization is taking place all along the busy National Highways. The northern part of the city has less habitation and currently going under new urban developmental activity. The Aligarh Muslim University, the prominent part of the city was once on the northern edge of the city, now it is surrounded by new urbanization and is currently in middle of the city [12]. Upper Ganga canal passes through in the Northern part of the city, while the southern part of the city has low lying area of the canal and this area is largely affected by saline soil. In the South eastern direction, the famous tourist cities Mathura and Agra are situated. Busy Delhi – Kanpur and other highway (Aligarh-Matura-Agra), National Highway and Railway passes through the main city.

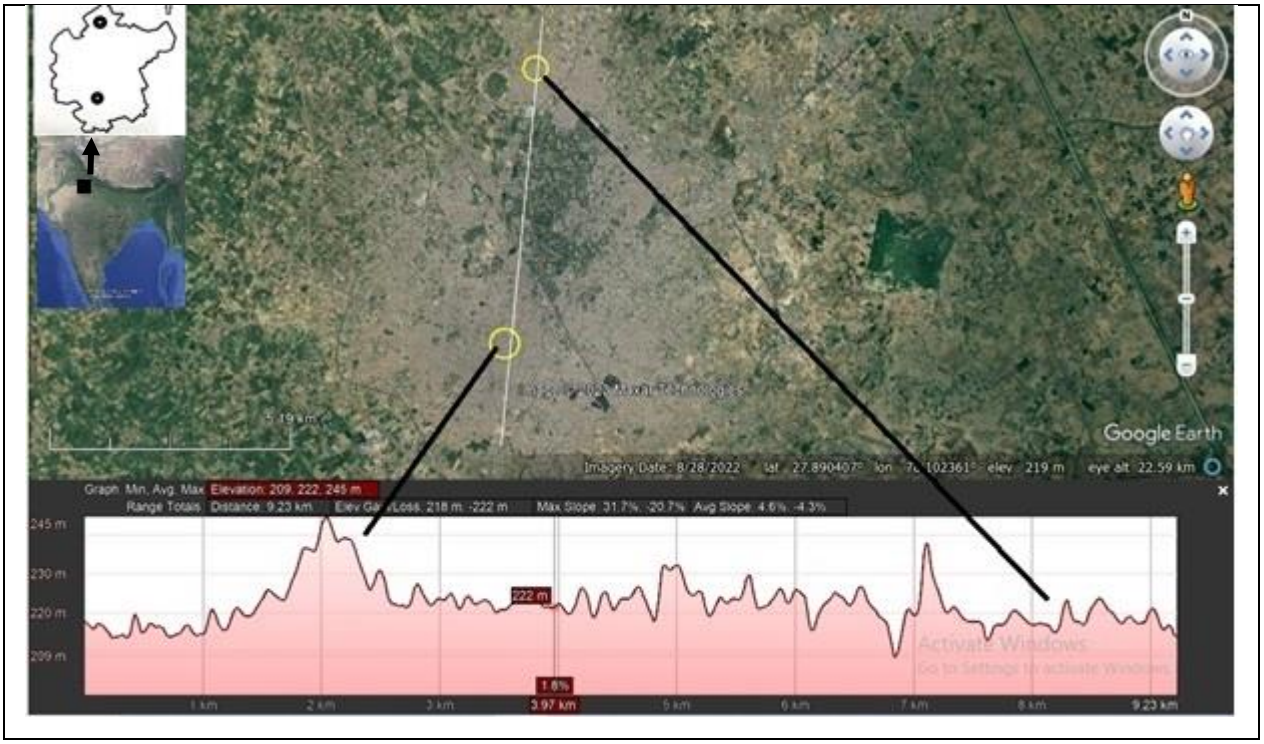

Figure 1: Location map of the study area along with elevation profile

2.1 Climate

The area is located on the fringe area of the arid zone (Rajasthan) and falls under the semi-arid climatic conditions. Climate in the area can be marked with distinct five seasons winter, spring, summer, monsoon and autumn. The winter prevails for three months (December – February). During this time, area is under influence of western disturbances and receive winter showers and foggy conditions prevails in the December and January. The spring season prevails hardly for two months (March –April) with moderate dryness and temperatures. The summer prevails for about three months (May – June) with high dryness and strong hot winds from South Western direction from Arid land in Rajasthan. These winds bring dust and caused to high dust concentration in June - July. Monsoon season (July – September) in the area is characterized by high humidity and rainfall. Autumn season (October to November) in the area commence after retreat of monsoon. In one climatic year the atmosphere events show high concentration of dust in June and foggy conditions in December and January.

3. Data and Methodology

A comparative study has been conducted for the average minimum and maximum daily air temperature observed in urban environment characterized by different elevation in the same city. Monthly min. and max. daily temperature were calculated using daily min and max air temperature observed at above said locations and presented in figure 1. Higher elevation urban area selected in upper court with 207 amsl and lower altitude is situated in Jamalpur with the elevation of 184 amsl in Aligarh city. These two locations are 4 km apart and enjoy same hydrometeorological conditions and same urban characteristics.

4. Results and Discussion

Daily minimum and maximum air temperature were collected for the period from 20 February to May 2020. A detail of temporal variation in atmospheric temperature at higher and lower altitude are presented in figure 2. The detail summery of the average daily minimum and maximum temperature at higher and lower altitude in Aligarh city is given in table 1and presented as Box and Whisker plot (fig.3). Based on data the thermal differences have been calculated for the high and lower altitude locations and presented as schematic figure 4. The average min. daily temperature difference lower and higher elevation is 0.0 ^{0}C in February, 0.60^{0}C in march, -0.80^{0}C in april and -0.50^{0}C in May. However, thermal differences of max temperature in between the lower and higher elevation is 0.5^{0}C in February, 0.19^{0}C in March, -0.7^{0}C in April and -0.35^{0}C in May.

In the month of February, 2020, the schematic diagram not indicated any significant difference in min. air temperature at different elevation. But the max temperature indicated a higher temperature associated with higher elevations and low temperature at low temperature. As season progresses in the month of March the monthly min and max. temperature is observed higher at higher altitude and lesser at lower altitude. A major reversal is observed in monthly avg. max and min temp. during the months of April and May. During these two months relatively, lower temperature prevails at higher elevation and higher temperature at lower elevation. Based on the monthly average min. and max temperature of four months suggests that elevated part enjoy higher temperature in winter and lower temperature in summer period.

Annual dynamic change in weather system and local topographic interactions were used in explaining the variability in temporal - spatial air temperature in winter and summer months. Variation in near surface temperatures are known to occur over topographically undulated terrain,

associated with stable night time conditions [13]. Particularly during winter min. temps. are recorded low in local depression late in night. As radiative heating is weak, daytime thermally induced flows may not be strong enough to heat these cold pools. This result in persistent cold spot and temperature inversions at lower elevation [7], [14], [15]. This cold pool is most mature in deep valley and marginal cold pool expected in shallower valley. A very shallow cold air pool could be developed due to long wave radiation loss from surface [16] (Rakovec et al., 2015). According to [17] cold pool strength increases with the sky view factor in the valley. In present study the mini. Temp. at lower elevation is due to thermal winter inversion in night time but disappear during day time when max. temperature observations. In cold winter night the thermal stability reflect in minimal differences in minimum air temperature at both elevations and slight warming is observed at higher elevation for the maximum temperature. However, as the day progress the insolation warm the buildings in the convex part readily warm up at higher elevation and the concave part received less radiation and consequently lesser temperature at lower altitude.

Table 1: Daily average minimum and maximum temperature observed at higher and lower altitude in Aligarh city during 2020. (H.Alt. High altitude, L.Alt. Lower altitude in the study area).

Months	H.Alt. Min. Temp ^{0}C	L.Alt. Min. Temp ^{0}C	H.Alt. Max. Temp ^{0}C	L.Alt. Max. Temp ^{0}C
February	18.286	18.286	22.571	22.000
May	25.100	25.600	38.700	39.050
April	21.683	22.517	36.300	37.033
March	18.839	18.274	28.032	27.839
February	18.286	18.286	22.571	22.000

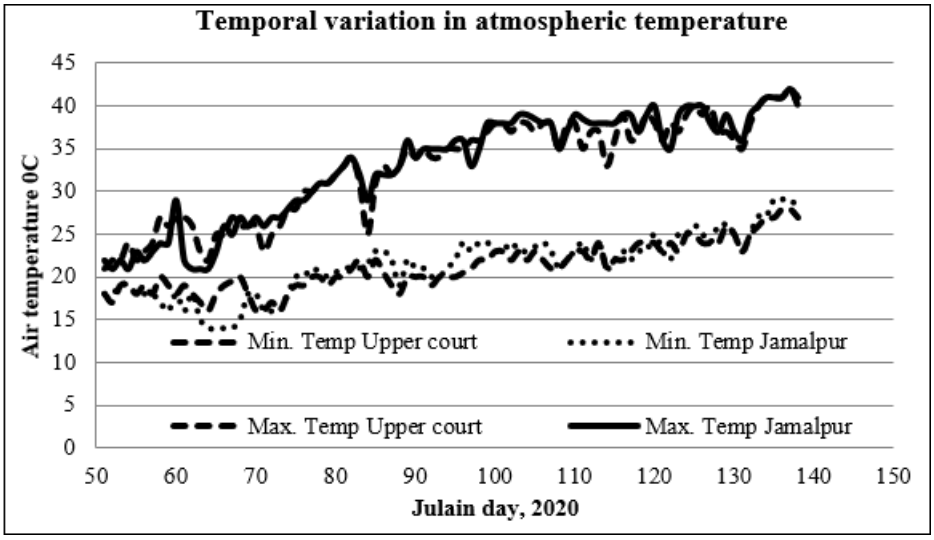

Figure 2: Temporal variation in atmospheric temperature

As the season progress in summer season of April and May, the lower elevation showed higher temperature than the elevated part of the city. Higher elevated slope of landscape, overlapping of buildings shadows and lower dragging force of wind at higher elevations resulting to lesser air temperature than surrounding low elevation surrounding. Lower temperature at elevated temperature is also the result of few interactions of air masses at buildings situated on slopes. These geometry helps to expose buildings to air and less stay of hot air along with more air velocity at higher elevation. The present study indicates that the dense population at higher elevation may escape the high heat in summer months. While the same area exhibits the higher temperature during winter months. The highland of old town enjoys ameliorated winter and escape summer heat during summer. These special locations in the Indo-Gangetic plains were utilized by planner in medieval period for town planning.

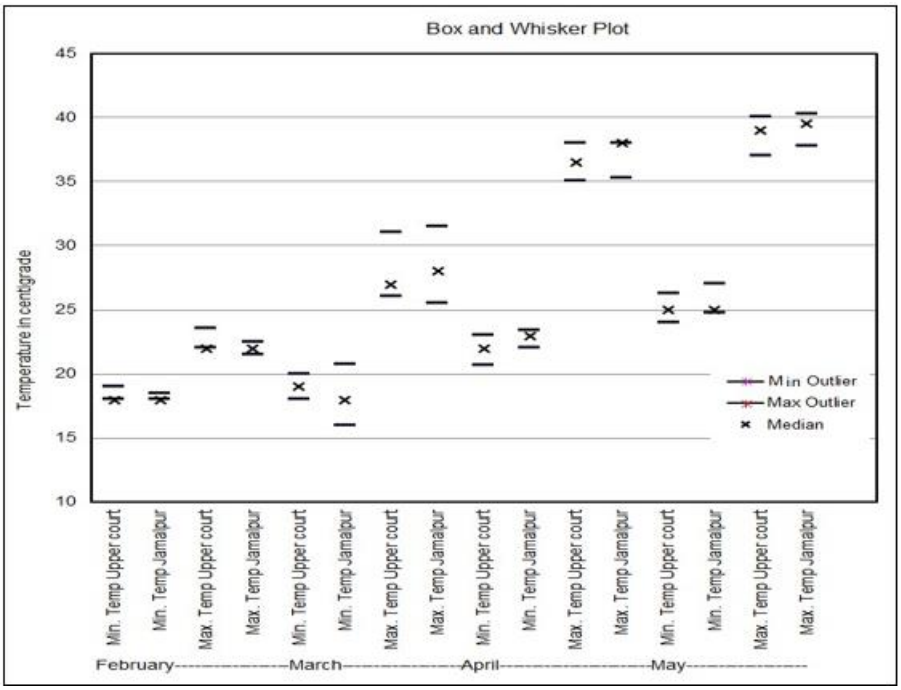

Figure 3: Spatial and temporal distribution of atmospheric temperature in Aligarh city during 2020

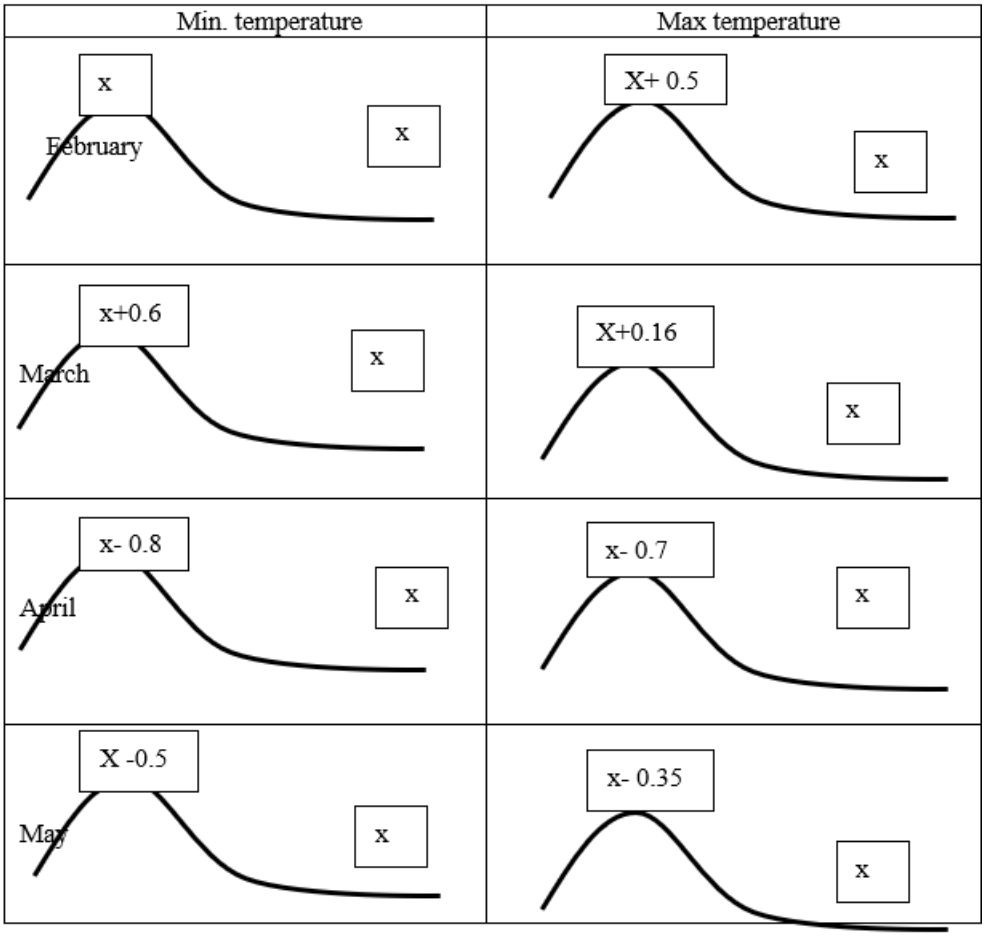

Figure 4: Schematic diagram showing the spatial and temporal variation in air temperatures with in Aligarh city

5. Conclusions

Convex shape of elevated and concave for the lesser elevated part in the city results in differential activity of radiation budget that resulting to readily warming at elevated part than lower elevation in winter period. Topography variation in urban area influence the geometry of buildings that help in creating more exposure to sun, wind and shadow effect in elevated part of the city that contribute to cooling effect in summer period. High air velocity at higher elevation along slope and lesser dragging fore result to lesser residence of air masses and keep the air cool than the surrounding lower

elevation in summer period. The elevated portion of city experience bit warmer in winter and cooler during summer in the undulated terrain in Aligarh city situated in north India. These ameliorated microclimate at higher elevation favored the selection criteria for developing the new cities in Indian continent.

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Author Profile

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