May. 2014. Vol. 2. No.1 ISSN 2311-2484
International Journal of Research In Earth & Environmental Sciences

http://www.ijsk.org/ijrees.html

THE INFLUENCE OF TOPOGRAPHY ON THE DISTRIBUTION OF URBAN HEAT ISLAND EFFECT IN CALABAR METROPOLIS.

Eni, Devalsam Imoke[1], Upla, Joseph Ibu[1], Ubi,Arikpo Etta[2]

Department of Geography and Environmental Science, University of Calabar, Calabar Nigeria.[1]
Cross River State College Of Education Akamkpa[2]
E-mail: Imokeeni @ yahoo.com

Abstract

Anthropogenic activities and modification of landscapes in the city of Calabar have impacted on the micro climate as a result of rapid urbanization which has caused urban heat island. The study seeks to examine the influence of topography on the distribution of urban heat Island in Calabar. Temperature readings were obtained in-situ from designated areas hourly between 12pm-6pm for three consecutive days. The co-ordinates and elevation of each sample point was obtained using the Global Positioning System (GPS). Metre tapes were used to measure distances along transects lines. The study reveals that temperature readings varies for high and low elevation and the intensity of urban heat Island depends on the cooling rate of the environment because, the urban area is made up of different surfaces which cools and heats up differently. Elevation was seen to increase as you move towards the North Pole and topography forms a depressed zone which coincides with the central business district (CBD). The result revealed that topography plays a very vital role in the formation of urban heat Island. The researchers therefore recommended that re-orientation of full buildings, landscaping, afforestation around buildings and the location of urban areas in an energy efficient manner can minimize the effect urban heat Island through the lowering of the release of greenhouse gases.

Keywords: ***Urban heat, temperature, topography, elevation and landuse.***

Introduction

The influence of topography and differential heating on the atmospheric process has long been a subject of interest to climatologist. The excitation of waves due to topography results in enhanced upward motion which can lead to formation of clouds and precipitation. The presence of waves can significantly influence the location and intensity of the clouds (Banta, 1990). The urban heat Island effect has been the subject of numerous studies in recent decades, because it is associated with temperature of urban locations rising several degrees above those of the nearby rural areas with similar elevation and topography (Chou, 1995).

High rates of urbanization have resulted in rapid, land use and climate changes. The growth and expansion of cities results in the construction of roads and other infrastructures to accommodate the growing population, this in turn destroys the natural landscape (Marsh and Grossa, 2002). Gray and Fisher (1999), opines that urbanization of the natural landscape through the replacement of vegetation with bridges, houses, surface encrusting structures and commercial buildings has drastically altered the temperature profile of urban areas. The composition and structure of the urban centres largely determines the thermal behaviour of cities. Heat effect manifests in large scale biophysical changes which affects the landscape albedo through a complex set of relationship involving changes in the land core, air quality, hydrology and climatic regimes of the area. A dominant factor in the identification and characterization of the urban-rural temperature divide is the temperature difference which varies spatially and temporally. This indicates that increased urbanization, brought about by demographic changes and attendant incidents of industrialization have caused remarkable increase in the temperature profile of urban centres. The dynamics and magnitude of urban climate changes may be a function of land use, and coverage, location, topography and environmental controls (Marsh and Grossa, 2002). The diverse land use activities undertaken, in the urban areas are expected to produce a mosaic of topoclimatic responses which means that even within the urban

ISSN 2311-2484
International Journal of Research In Earth & Environmental Sciences

http://www.ijsk.org/ijrees.html

micro climate, there may still be individual micro scales of heal Islands.

In Calabar, it is believed that topography, cloud cover, soil and thermal conductivities are the major factors that accelerate the processes of urban heat Island and it varies over the landscape scenery due to the combine influence of seasonality, hydrology and topography. Reconnaissance survey revealed a widespread outcry from residents concerning heat stress which is more pronounce in the months of February and April and it is regular around areas with high population nuclei. It was observed that in Calabar, there is a great deal of thermal variation with the urban region related to different land uses and surface material. The heat released to the atmosphere as water vapour, is reduced while sensible heat is increased. The study area is characterized by two forms of changes which are; the flushing capacity of the air at ground level which is reduced with the construction of tall and closed spaced buildings and the problem of emission from building, heating and conditioning systems which drastically increase the heat effect.

The thermal properties of the built up land surfaces, soil and imperious surface will result in more solar energy being stored and converted to sensible heat and the removal of shrubs and trees reduces the natural cooling effects of shading and evaportranspiration (Picket *et al*., 2001). Urban heal differential is a function of urban topography, surface roughness, morphology of buildings and anthropogenic activities which contributes to urban heat Island by reducing the outgoing long wave radiation, hinder sensible heat loss, hinder distribution of heat and the generation of heat respectively. This condition leads to increase in sensible heat flux at the expense of latent heat flux, thereby forcing the development of meteorological events such as increased precipitation which poses a threat to the environment and human population.

The role played by topoclimatic factors such as topography, relief, urban structure, intensity of buildings, differences of albedos, roughness, thermal capacities are all key factors that have accelerated the incidence of urban heat Island in the study area. The researchers aim is to investigate the relationship existing between topography and urban heat Island effect. Findings from this study will illuminate the true nature of the heat mosaics within Calabar.

Study area

Calabar is located between longitude 008^{o}18^{o} E and 008^{o}20’E and latitude 4^{o}45’N and 4^{o}50’N. It is bounded in the South by the Atlantic Ocean and to the North by Odukpani Local Government Area, in the West; it is bounded by the Calabar River and to the East by Akpabuyo Local Government Area. Udo (1970), described Calabar landscape formation as belonging to the Old Benue Basin formed around the cretaceous period of oceanic transgression. Ofomata (1975), categories the Calabar geological formation into two categories namely; the cretaceous sedimentary formation and the Basement complex formation. The cretaceous formation is incomformity with the Basement complex and it appears around Odukpani Local Government Area. The relief is hilly and undulating and has a gentle slope which varies from zero percent to about 20 percent in some areas. Elevated areas are predominated in the East with prominently North-South tending orientation. The relief has a characteristically elevated coastal margin in areas around Marina road but lower in areas such as Anatigha in the Qua River valley.

Calabar falls within tropical equatorial climate with high temperature, high relative humidity and abundant annual rainfall (Oguntoyimbo, 1978). The tropical maritime and the tropical continental air masses affect the climate in two distinct seasons. Tropical maritime air prevails and influences its atmosphere characteristics while the tropical continental air masses influences the dry season condition due to its desert source region and the temperature characteristics which is cool and dry. The two air masses meet at the pressure front called inter tropical discontinuity (Oguntoyimbo, 1978). Insolation effect is quit high and it is caused by the sheer factors of its tropical location as well as the activities of urban developement which have significantly altered the land cover.

Rainfall is of the double maxima (double peak) regime with peaks in July and September depending on the yearly weather cycles. Rainfall duration spans over 9-10 months of the year but is somewhat sporadic during the dry season. The dry season weather or the harmattan season produces depression due to the cool – dry temperature and moisture characteristics of the continental air mass. The annual temperature is 21.6^{o}C and the relative humidity is 85 percent. Calabar is a fast growing urban settlement based on the development of residential, commercial, administration, and educational, recreational, theological and financial enterprise. The current rate of urban expansion is seen by the comparative manner of land acquisition and the rapid rate at which the suburbs are being invaded for settlement development. The present land use pattern deviates fundamentally from the initial plan due to increased demand for residual landuse which has led to the reallocation of institutional as well as industrial land to residual property development. As at 2006 National Population

May. 2014. Vol. 2. No.1 ISSN 2311-2484
International Journal of Research In Earth & Environmental Sciences

http://www.ijsk.org/ijrees.html

Census, the population of Calabar stands at 370,292.

Materials and methods

Data collection procedure involved in-situ temperature readings at designated areas in the study location. Air photo maps were used in mapping land use types and landscape characteristics for field data acquisition based on temperature records. The types of data used include linear and areal measurement, land use information, landscape types,and metre tape was used to measure distance along transect lines. Ordinary dry bulbs thermometers were used in the measurement of in-situ temperature. Global positioning system was used to determine heights and co-ordinates of sampled locations also it was used in measuring elevation to depict the topography characteristics. The areas covered were Eleven-Eleven Bus Stop, Etim-Edem Park, Watt Market, Murtala Mohammed Highway, Calabar Road, Ndidem Usang Iso, Parliamentary Road, Etta Agbor, Mount Zion, Atimbo Road, IBB Road, Airport Road, Mary Slessor, White House and Ekpo Abasi, etc. These streets were identified during the reconnaissance survey.

Transect was used to obtained temperature profile of the area, at each point, readings were obtained for elevation and coordinates respectively. Mapping points were purposively selected in line with the specific landscape. The temperature readings were taken hourly with the help of field assistance. Temporal differences in urban heat incidence were explored based on the data derived from both secondary and primary sources. The secondary source was obtained from a four year record acquired by the Nigerian meteorological services (NIMETS) in Calabar, while the primary source was obtained from in-situ measurements at the study locations. Days with clear skies and calm winds were chosen for the study.

Discussion of findings

The results obtained from the study were recorded in tables as shown below.

Table 1: Transect mapping of urban heat incidence in Calabar

S/N	*Locations*	*Distance from central business district (CBD)*	*Land cover/ surface fabric*	*GPS coordinates*	*Hourly temperature readings (°C)*					
					T2-1pm	*1-2pm*	*2-3pm*	*3-4pm*	*4-5pm*	*5-6pm*
1.	*Eleven-eleven Bus stop*	*700m*	*Tamac surface*	*Elevation = 169m* *N = 04°57'* *E = 008°19'*	*32.5* *33.4* *24.2*	*33.1* *32.2* *34.2*	*34.5* *32.2* *33.3*	*33.5* *32.3* *34.6*	*32.6* *33.3* *32.5*	*32.2* *34.4* *35.5*
2.	*Etim Edem Park*	*500m*	*Open concrete surface*	*Elevation = 149m* *N = 04°57'* *E = 008°19'*	*35.4* *27.3* *28,3*	*30.5* *32.5* *31.6*	*30.5* *31.6* *32.4*	*32.5* *33.6* *31.0*	*33.2* *33.5* *35.4*	*30.5* *31.4* *32.5*
3.	*Watt Market*	*200m*	*Crowded built-up surface*	*Elevation = 162m* *N = 04°56'* *E = 008°18'*	*32.5* *33.2* *31.4*	*29.5* *35.1* *27.3*	*30.2* *31.4* *28.4*	*29.4* *30.2* *31.6*	*31.4* *31.2* *29.6*	*29.4* *30.2* *31.3*
4.	*Murtala Mohammed Highway*	*5000m*	*Open Tarmac surface*	*Elevation = 145m* *N = 04°59'* *E = 008°20'*	*26.5* *28.6* *32.1*	*29.6* *30.2* *32.5*	*28.5* *31.6* *32.2*	*30.6* *31.2* *33.2*	*28.7* *30.3* *29.6*	*28.5* *32.4* *36.4*
5.	*Calabar Road*	*400m*	*Crowded built up tarmac surface*	*Elevation = 161m* *N = 04°57'* *E = 008°19'*	*28.5* *31.5* *30.6*	*31.4* *32.4* *33.5*	*29.4* *30.1* *33.3*	*34.5* *33.2* *34.3*	*28.6* *30.1* *29.7*	*35.3* *29.3* *30.2*
6.	*Ndidem Usang Iso*	*2000m*	*Open tarmac surface*	*Elevation = 227m* *N = 04°56'* *E = 008°20'*	*24.5* *28.0* *31.2*	*35.6* *34.3* *27.6*	*30.6* *27.4* *29.3*	*29.2* *30.1* *31.2*	*30.4* *31.2* *21.6*	*30.5* *32.1* *31.4*
7.	*Parliamentary Road*	*5000m*	*Open tarmac surface*	*Elevation = 180m* *N = 04°01'* *E = 008°21'*	*32.5* *33.2* *30.1*	*29.6* *30.1* *27.2*	*34.3* *32.2* *31.0*	*35.5* *32.4* *29.6*	*29.4* *30.6* *27.4*	*30.5* *30.3* *29.6*
8.	*Etta Agbor Road*	*1000m*	*Crowded built-up concrete surface*	*Elevation = 218m* *N = 04°57'* *E = 008°20'*	*31.5* *32.3* *33.4*	*31.3* *32.6* *33.2*	*29.3* *30.1* *32.3*	*30.1* *32.2* *29.6*	*29.6* *30.2* *31.4*	*31.2* *32.0* *31.0*
9.	*Mount Zion Road*	*3000m*	*Dense traffic tarmac surface*	*Elevation = 151m*	*29.5* *24.0*	*31.6* *30.4*	*30.5* *29.3*	*30.2* *33.2*	*29.6* *30.1*	*30.4* *31.3*

May. 2014. Vol. 2. No.1 ISSN 2311-2484
International Journal of Research In Earth & Environmental Sciences

http://www.ijsk.org/ijrees.html

				N = 04°57’ *E = 008°19’*	*29.6*	*30.5*	*28.2*	*31.0*	*26.1*	*32.4*
10.	*Atimbo Road*	*800m*	*Open tarmac surface*	*Elevation = 151m* *N = 04°57’* *E = 008°20*	*32.1* *30.1* *29.2*	*30.5* *27.6* *31.5*	*33.4* *31.2* *30.1*	*28.6* *30.1* *29.2*	*29.3* *30.2* *28.4*	*30.1* *32.3* *31.2*
11.	*IBB Road*	*1500m*	*Dense traffic tarmac surface*	*Elevation = 181m* *N = 04°57’* *E = 008°20’*	*26.2* *29.3* *30.2*	*29.6* *31.4* *27.7*	*34.5* *32.2* *30.1*	*30.2* *31.4* *32.5*	*30.1* *31.2* *30,3*	*29.1* *28.0* *30.5*
12.	*Airport Road*	*1000m*	*Tarmac surface*	*Elevation = 151m* *N = 04°57’* *E = 008°20’*	*30.4* *32.5* *33.6*	*29.5* *30.5* *31.5*	*32.5* *34.6* *29.5*	*33.4* *32.3* *31.5*	*32.6* *34,5* *31.5*	*31.5* *30.5* *33.3*
13.	*Mary Slessor*	*2500m*	*Dense traffic tarmac surface*	*Elevation = 152m* *N = 04°57’* *E = 008°19’*	*34.5* *32.4* *25.6*	*33.5* *32.6* *34.5*	*29.5* *30.6* *31.0*	*28.5* *31.7* *32.2*	*26.5* *31.5* *33.4*	*24.2* *30.4* *32.3*
14.	*White House*	*1200m*	*Open concrete surface*	*Elevation = 168m* *N = 04°56’* *E = 008°19’*	*33.6* *32.3* *33.2*	*32.5* *33.6* *32.2*	*29.5* *30.5* *31.2*	*28.6* *31.5* *32.4*	*30.5* *31.2* *30.5*	*28.2* *29.6* *30.1*
15.	*Ekpo Abasi*	*3000m*	*Tarmac surface*	*Elevation = 56m* *N = 04°55’* *E = 008°19’*	*30.5* *31.3* *32.2*	*31.5* *33.4* *36.5*	*32.4* *31.5* *30.4*	*28.9* *29.5* *30.5*	*30.2* *31.3* *30.5*	*28.5* *29.5* *30.5*

Table 1 revealed that urban heat Island occurred mostly on tarmac and concrete surfaces. The spatial variation of temperature within the study area is explained by their different elevations. Elevation which is a function of topography ranged from 76m at Ekpo Abasi to 218m at Etta Agbor road. The most depression point is located at the southern part of Calabar. The elevation increases as you move n\towards the North. It was observed that topography forms a depressed bottom which tallies with the Central Business District (CBD). The research showed that the relief and topography of the city has relevance in the explanation of the temperature distribution within the city centre. A good knowledge of these parameters can help in the determination of areas that are suitable for urban growth and expansion. The temperature readings ranged from 26.2^{o}C – 35.3^{o}C for hourly readings taken between 12pm – 6pm. The growth and intensity of urban heat Island depends on the cooling rates of the urban environment, because the urban area is composed of different surfaces which heats up and cool down differently. This study further revealed that the growth of urban heat Island intensity varies between the day and night time and the heat Island was visible over major built up areas. In the dry season there is always a high demand for electricity for utilization of forms and air conditioners in order to create comfort, but the urban heat Island magnifies this demand by using up more energy for cooling of buildings. This activity accelerates the release of greenhouse gases and it results in climate change. The study indicates that the study area was characterized by buildings with greater absorptive power, dark roofs, non-reflective surfaces, and paving materials that do not absorb. The result posits that topography played an important role in the formation of urban heat Island.

Table 2: Effect of topography on heat

S/N	*Locations*	*Land cover/ surface fabric*	*High Elevation*						*Low Elevation*					
			T2-1pm	*1-2pm*	*2-3pm*	*3-4pm*	*4-5pm*	*5-6pm*	*T2-1pm*	*1-2pm*	*2-3pm*	*3-4pm*	*4-5pm*	*5-6pm*
1.	*Eleven-eleven Bus stop*	*Tamac surface*	*34.5* *32.6* *32.2*	*34.2* *33.4* *31.2*	*30.4* *31.5* *32.5*	*34.0* *31.0* *33.5*	*34.2* *33.3* *35.6*	*33.6* *35.5* *34.4*	*26.5* *27.3* *28.4*	*30.2* *29.5* *26.5*	*25.6* *24.6* *25.4*	*28.6* *27.5* *26.2*	*28.2* *25.3* *24.5*	*23.2* *24.5* *25.3*
2.	*Etim Edem Park*	*Open concrete surface*	*32.3* *31.5* *34.3*	*34.5* *32.3* *32.1*	*30.4* *29.5* *31.2*	*31.5* *28.4* *27.5*	*32.5* *31.4* *32.4*	*31.2* *33.3* *31.4*	*27.6* *25.3* *24.5*	*26.5* *24.5* *24.0*	*25.1* *25.3* *24.5*	*25.5* *24.3* *23.6*	*23.2* *24.3* *25.6*	*25.3* *26,3* *27.4*
3.	*Watt Market*	*Crowded built-up surface*	*33.2* *31.3* *30.4*	*33.4* *32.3* *32.5*	*33.2* *32.4* *31.0*	*28.0* *29.5* *30.6*	*31.2* *30.2* *31.3*	*33.2* *34.5* *31.2*	*28.3* *24.4* *26.4*	*23.4* *25.5* *26.0*	*23.5* *24.6* *25.3*	*22.5* *24.5* *25.6*	*25.0* *26.2* *27.3*	*24.5* *25.7* *26.5*

May. 2014. Vol. 2. No.1 ISSN 2311-2484
International Journal of Research In Earth & Environmental Sciences

http://www.ijsk.org/ijrees.html

4.	Murtala Mohammed Highway	Open Tarmac surface	33.0 32.2 31.5	33.6 32.4 31.3	32.4 31.0 29.4	31.7 32.6 30.1	30.2 32.3 31.4	30.1 29.2 31.3	26.5 27.0 24.5	25.0 26.4 24.5	26.0 24.4 23.5	25.5 24.5 23.6	23.4 25.0 24.3	25.0 24.6 23.5
5.	Calabar Road	Crowded built up tarmac surface	35.2 31.4 32.5	34.2 32.3 33.4	30.2 31.4 32.5	29.2 30.5 31.2	30.4 31.5 29.6	27.4 29.3 26.5	25.4 23.0 26.5	26.6 26.7 27.8	28.5 29.4 24.0	26.5 24.4 23.0	25.4 26.0 27.2	24.6 25.3 27.4
6.	Ndidem Usang Iso	Open tarmac surface	34.2 32.5 33.0	35.6 32.1 34.3	31.4 31.0 30.2	31.2 32.6 33.7	29.7 31.4 32.5	29.4 26.0 27.3	27.3 28.2 29.5	29.5 28.3 27.4	26.5 26.4 25.0	27.4 25.4 24.5	28.4 26.5 29.2	23.4 25.5 24.0
7.	Parliamentary Road	Open tarmac surface	31.5 32.4 30.2	32.5 34.2 33.2	30.4 31.5 32.6	31.2 32.0 33.4	33.4 34.5 31.0	32.4 31.5 30.4	29.5 27.3 26.2	27.5 26.0 25.5	29.0 25.5 24.3	26.5 27.0 28.1	24.6 25.7 25.1	26.7 24.5 25.2
8.	Etta Agbor Road	Crowded built-up concrete surface	32.4 33.5 31.2	31.2 30.4 29.3	32.5 33.6 28.2	30.2 31.2 29.3	29.6 30.2 31.2	31.2 32.3 34.5	25.3 25.4 26.1	25.2 25.4 24.3	25.3 26.4 27.4	28.2 29.4 30.2	24.5 25.6 24.3	25.3 26.4 27.3
9.	Mount Zion Road	Dense traffic tarmac surface	35.4 32.5 33.4	28.3 28.6 30.4	29.4 31.2 33.4	28.9 30.1 31.2	32.4 33.2 29.3	31.4 32.5 30.1	26.3 23.4 25.3	27.3 29.3 28.4	26.3 25.4 25.0	31.2 30.1 27.3	25.0 26.4 27.5	28.3 25.2 27.3
10.	Atimbo Road	Open tarmac surface	31.2 32.4 31.0	30.6 31.2 32.4	34.5 26.6 31.0	32.4 32.5 31.3	28.2 30.1 31.4	29.5 31.6 30.4	28.3 28.2 27.9	29.2 30.1 31.2	24.3 25.6 24.4	26.4 25.4 26.3	28.3 25.6 28.6	24.5 25.6 24.3
11.	IBB Road	Dense traffic tarmac surface	32.4 31.3 34.2	31.4 33.0 32.5	32.5 33.0 34.2	29.8 28.4 30.1	32.5 33.4 30.1	31.4 32.5 32.0	30.1 29.2 28.2	30.4 26.2 27.2	24.5 27.2 24.5	24.5 27.3 28.5	25.5 26.3 27.2	30.1 31.2 25.3
12.	Airport Road	Tarmac surface	32.2 31.5 33.2	30.2 31.2 34.5	31.5 30.6 31.7	31.4 32.5 32.0	25.40 29.50 30.1	33.0 31.6 29.0	31.2 32.3 30.1	29.6 28.4 27.3	26.5 27.4 25.3	26.0 28.3 27.4	26.5 28.3 25.2	25.5 26.4 27.3
13.	Mary Slessor	Dense traffic tarmac surface	32.4 33.1 31.2	30.7 32.2 34.1	31.6 32.5 33.2	32.5 33.4 31.2	31.5 32.3 33.5	29.5 30.1 31.4	24.5 26.5 27.3	25.4 28.6 24.2	25.4 23.4 22.6	25.6 27.4 23.4	29.3 27.2 26.2	28.3 27.2 28.2
14.	White House	Open concrete surface	33.3 32.4 31.2	30.2 31.3 32.4	33.7 34.5 29.4	29.5 31.4 32.3	28.4 30.5 31.4	32.5 34.2 31.4	25.2 24.3 30.1	23,4 24.5 26.2	26.1 25.2 24.2	28.3 29.0 25.6	24.4 25.4 28.3	24.5 25.5 26.3
15.	Ekpo Abasi	Tarmac surface	33.6 32.2 31.4	34.6 34.3 31.4	33.5 31.5 30.4	29.4 31.9 32.0	32.4 35.8 31.0	26.0 28.5 29.2	31.3 25.3 27.4	26.4 23.5 24.4	27.3 25.3 26.4	28.6 27.4 26.5	28.3 29.4 24.6	28.5 27.6 28.5

Table 2 above that revealed that there is influence of topography and differential heating on atmosphere processes. The study indicates that environmental variables have an important influence in the occurrence and intensity of urban heat Island and it tries to explain why temperature readings in some areas are less influenced by elevation. The findings showed that the temperature readings obtained from the high elevated topography varies with that recorded at the low elevated topography. Urban heat effect has manifested in a large scale biosphysical changes which affects the landscape albedo through a complex set of relationship involving changes in this land cover, air quality, hydrology and climatic regimes of the study area. The major causes of urban heat Island in Calabar includes the following short were radiation, decrease outgoing long-wave radiation, heating of sides and tops of buildings, and reduced evapotranspiration as a result of increased deforestation for development purpose.

ANOVA was then used to compare the temperature variation with elevation, by using this hypothesis which states that, there is no significant variation in the temperature readings taking at different elevation levels in the study area.

Table 3: ANOVA for temperature readings and elevation values

Source of variation	ss	df	ms	F	p-value	f-crit
Sample	90.65384	3	31.742	1.456789	0.1578365	2.5688456
Columns	51453.38641	5	8552.13	282.9676	6.234554	2.1434567
Interaction	814.22110	15	43.2466	2.2045	0.0254346	1.54328819
Within	1341.2233	58	20.1234			
Total	**53704.484**	81				

Decision

The result from table 3 showed that the calculated F-value (2.002) is greater than the critical F-value of (1.54). This means that the null hypothesis is rejected while the alternate hypothesis is accepted. Which states that there is a significant variation in the temperature readings taking at different elevations within the study area at 0.05 confidence level?

Conclusion

Urban heat Island is a contemporary problem facing the urban centre and cities which needs an immediate attention. There is need for proper planning of cities centres to ensure a healthy physical environment and reduce the challenges of climate change to the bearest minimum. Human activities in the cities affect the microclimate and modify it as developmental processes escalate. The magnitude of roads, high buildings, industrial processes, air conditioners and transportation, modification, re-orientation of buildings in the cities, landscaping, vegetation around buildings and locating urban areas in an energy efficient manner can go a long way to decrease greenhouse gas emissions and temperature values which are the major causative factor of urban heat Island.

References

1. Arnfield, A.J. (2003). Two decades of urban climate research a review of turbulence, exchanges of energy and water, and the urban heat Island. *International Journal of Climatology*, 23: 1-26.

2. Bruintjes, R.T., Clark, T.L. & Hall, W.D. (1994). Interactions between topographic air flow and cloud//precipitation development during the passage of a winter storm in *Arizona J. Atoms. Sci. 51*: 48 – 67.

3. Carruthers, D.J. & Hunt, J.C.R. (1990). Fluid mechanics of airflow over hill; turbulence, fluxes and waves in the boundary layer. In: *Atmospheric Processes over Complex Terrain* (Chapter 5), AMS (1990).

4. Chander, T.J. (1970). Urban climatology. Symp. WMO Tech. Note No. 108. WMN No. 254, Geneva.

5. Clark, T.L. & Hall, W.D. (1991). Multi-domain simulations of the time dependent Navier-Stokes equations bendmark error analysis of some nesting procedures. *J. Comp. Phys.* 92: 456 – 481.

6. Cowry, W.P. (1977). Empirical estimation of urban effects on climate – A problem analysis. *J. Appl. Met*., 16: 129 – 135.

7. Dimoudi, A. and Nikolopoulou, M. (2003). Vegetation in the urban environment midroclimatic analysis and benefits *Energy and Buildings*, 35: 69 – 76.

8. Fan, H.I. & Sailor, D.J. (2005). European topic centre on terrestrial environment (ETC/TE). Corine Land Cover, 2000.

9. Gallo, K.P., McNab, A.L., Karl, T.R., Brown, J.F., Hood, J.J. & Tarpley, J.D. (1993). The use of a vegetation index for assessment of the urban heat Island effect. *International Journal of Remote Sensing*, 14: 2223 – 2230.

10. Goward, S.N. (1981). Thermal behaviour of urban landscapes and the urban heat Island. *Physical Geography*, 2: 19 – 33.

11. Kim, Y.H. & Baik, J.J. (2005). Spatial and temporal structure of the urban heat Island in *Seoul. Journal of Applied Meteorology*, 44: 591-605.
12. Klaic, Z.B., Nitis, T., Kos,I. & Moussiopoulous, N. (2002). Modification of the local winds due to hypothetical urbanization of the Sagreb surroundings. *Meteorology and Atmospheric Physics*, 79: 1-12.

13. Klysik, K. & Fortuniak, K. (1999). Temporal and spatial characteristics of the urban heat island of Lodz, Poland. *Atmospheric Environment*. 33: 3885 – 3895.

14. Kunz, R. & Moussiopoulous, N. (1995). Simulation of the wind field in Athens using refined boundary conditions. *Atmospheric Environment*, 29: 3575 – 3591.

15. Landsberg, H.F. (1970). Climates and urban planning WMO Techn. Note No. 108.

16. Liang, S.L., Strahler, A.H. & Walthall, C. (1999). Retrieval of land surface albedo from satellite observations: A simulation study. *Journal of Applied Meteorology*, 38: 712 – 725.

17. Lipps, F.B. & Hemler, R.S. (1982). A scale analysis of deep moist convection and some related numerical calculations. *J. Atmos. Sci.* 39: 2192-2210.

18. Mason, P.J. & sykes, R.J. (1979). Flow over isolated hill of moderate slope. *Q.J.R. Meterol Soc.* 105: 383 – 395.

19. Murthy, B.P. (1979). Isothermal and isotherms in pune on clear winter rights. A Met. Study. *Mausam*, 30: 473 – 478.

20. Murthy, B.P. (1999). Hot cities in hot climate WMO. *Int. Conf. on Urban Climatology*, Sydney.

21. Newton, C.W. & frankhauser, C.J. (1975). *Movement and propagation of multicellular convective storms*. Pageoph, 113, Birkhaeuserverlag Basel.

22. Nitis, T.D, Kitisiou, Z.B., Klaic, M.T., Prtenjak, Moussipoulous, N. (2005). The effects of basic flow and topography on the development of the sea breeze over a complex coastal environment. *Quarterly Journal of the Royal Meteorological Society*, 131: 305-327.

23. Noillian, J. & Planton, S. (1989). A simple parameter station of land surface processes for meteorological models. *Mon. Wea. Rev.* 117: 536 – 549.

24. Oke, T.R. (1974). Review of urban climatology 1968. 73 UMO Tech. Note 134, WMO No 383, Geneva.

25. Oke, T.R. (1978). *Boundary Layer Climates*. Methuen, London, 435pp.

26. Oke, T.R. (1979). Review of urban climatology 1973. 76 UMO Tech. Note 134, WMO No 539, Geneva.

27. Oke, T.R. (1984). Methods in urban climatology. ETH Geog. Inst., Zurich.

28. Oke, T.R. (1987). Boundary layer meteorology, Routledge, New York.

29. Oke, T.R. (1999). Multitemporal remote sensing of an urban heat Island WMO. *Int. Conf.* on urban climatology, Sydney.

30. Poris, X. & Sole, L. (1994). A simple radiometric correction model to improve automatic mapping of vegetation iron multispectral satellite data. *Remote Sensing of Environment*, 48: 191 – 204.

31. Sailor, D.J. & Lu, L. (2004). A top-down methodology for developing diurnal and seasonal anthropogenic heating profiles for urban areas. *Atmospheric Environment*, 38: 2727 – 2748.

32. Saz, M.A., Vicente, S.M. & Cuadiat, J.M. (2003). Spatial patterns estimation of urban heat Island of Zaragoza (Spain) using Gis. *Fifth International Conference on Urban Climate* Lodz in this volume.

33. Shutts, G. & Broad, A. (1993). A case study of ice waves over the Lake District in Northern England. *Q.J.R. Metereol. Soc.* 119: 337-408.

34. Swaid, H. (1993). Urban climate effects of artificial heat sources and ground shadowing by buildings. *International Journal of Climatology*, 13: 797 – 812.

35. Thielen, J. & McLllveen, J.F.R. (1996). Topographical influence on severe convective storms. In: *Conf. Proceedings on the 2nd Int. Symp. Hdro. Applic. of Weather*. Radar, University of Harmover, September 7-10, 1992.

36. Upmans, H., Eliasson, I. & Lindqvist, S. (1998). The influence of green areas on nocturnal temperatures in a high latitude city (Goteborg, Sweden). *International Journal of Climatology*, 18: 681 – 700.