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Microclimatic Analysis and its Effect on Human Comfort: A Case Study of Minna, Niger State.

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Abstract.

One major pre-occupation of human climatology is to understand the effect of a given set of climatic conditions on the comfort level of individual. The modification of natural environment such as construction of buildings, roads and provision of open spaces are referred to as urban surfaces. All these coupled with human activities and industries, transportation and waste disposal have influence on the climate of the immediate environment to constitute city climate. City climates therefore provide the most extreme micro-climatic modifications which man has created. Looking at the present rate of urbanization and high rate of population explosion in tropical cities / urban centers, it is pertinent to study the relationship between human health and comfort and the various microclimatic parameters to determine the level of comfort ability or otherwise of these cities. The wide range of external and internal factors influences comfort of individuals and what is comfortable at one time to an individual may not be comfortable at a later time to the same individual. The paper made an attempt to determine the range of comfort in human beings who are exposed to different environmental conditions. Data used were collected from practical exercise on field study which was stretched from 7.00am to 7.00pm.Dry and wet bulb thermometers were used to collect air temperature from six (6) selected sampling areas within the city and 90 people of different sex, age, height and weights were interviewed to know their thermal sensation during the period covered .The data were computed using Effective Temperature (ET) and Relative Strain Index (RSI). The analysis of the result and responses showed that the environment was generally comfortable in the morning and towards the evening but hot and warm and not comfortable during the afternoon- though the level of comfort ability varies from one location to the other within the study area. Also, the study reveals that micro-climatic parameters like humidity, wind and temperature are more important in determining the comfort level of a given environment

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Introduction

The term climate refers to atmospheric conditions over long time periods, such as seasons, years, or decades, whereas the term weather conditions refers to shorter periods of time, such as hours, days or weeks. Climate depends in part on precipitation and temperature, both of which show tremendous variability on a global scale. The simplest classification of climate is by latitude, tropical, subtropical, midlatitudinal (continental), sub arctic and arctic. It is important to recognize the significance of potential climatic variability in determining the kinds of organism that lives where.

On a regional scale, air masses that cross oceans and continents can have a profound influence on seasonal patterns of precipitation and temperature. On a local scale, climatic conditions can also vary considerably and produce a local effect reoffered to a micro-climate.

Micro climate is the variations in the climatic conditions of a small area say few, few square kilometers. The vertical zone of the area is assumed to extend as far as the level reached by the tallest plants above the ground and below ground as far as the depth of the air penetrating into the ground (Ojo,1977).Various activities of man such as cooking, heating, factories and vehicular movements make a city to generate greater heat. A more extreme modification of micro-climates is that resulting from the building of cities. The varieties of shapes and orientation of the city building which composed mainly of rocky materials alter the natural landscape. Since shelter is one of the essentials of life and climate dependent, erecting buildings are essentials so as to create artificial indoor climates that are comfortable for people to live and work in (Ayoade 1988, Wahab 1995). One major pre-occupation of human climatology is to understand the effect of a given set of climatic conditions," the climate on the comfort of the individuals". The main climatic elements that affect human comfort are radiation, air temperature, humidity, sunshine hours and wind. Complete assessment of human comfort also requires information such as thermal conductivity of clothing, vapour pressure of the skin and metabolic heat rate due to activity of the human body (Hobbs, 1980)

There is considerable literature on the comfort, discomfort and thermal stress indices in relation to the climatic environment conditions (Landsberg 1990, Lafleur, 1991). The general principles underlying the evaluation of these indices to is to recognize that human health and comfort depend upon maintenance of a stable internal body temperature of 37oC and skin temperature at 33oC.To maintain these, heat gains must balance hat losses between man and his environment and these depend on the nature of the environment.

Also, the reaction of man to his environment has been a subject of interest to researchers who are concerned with thermal comfort for many years. Consequently, the term "comfort zone" was introduced between 1913 and 1923 by Hill (1993).Also, an American society of heating, refrigeration and air conditioning engineers (ASHRAE) carried out an experiment which led to the development of comfort chart. It was also in 1923 that temperature and humidity were combined into an index of thermal comfort called "Effective temperature (ET)", (Houghton, 1993). It is in line with these studies that this research paper has been undertaken and the aim is to determine the range of comfort in some selected areas in Niger State. Though, comfortability of a building depends upon the orientation of the building, the position of the rooms, the arrangement of the windows in relation to wind direction and atmospheric condition to which the people dwelling in the rooms are exposed to. The significance of this study will show the reactions of different combinations of climatic conditions by a number of human subjects of different ages and sexes and the way they are being

exposed to both indoor and outdoor. Also, the study reflects how human body responses to temperature and how wind exerts influence largely on human beings through its effect on skin temperature and body moisture. The willingness of planners to establish a building in relation to micro-climatic parameters of the environments of great significance.

Study Area.

The study was conducted in Minna, the capital city of Niger State, which is located approximately on longitude 40001 East and latitude 70001 North. It is found in the middle belt of the country. The drainage system of the entire state is divided into six major sub-catchment basins of river Niger. The division is based on the size of the basin, rivers draining into the river Niger which is the main river in the state. Rainfall distribution has a trough in August. Temperatures are about 280C on the average and this shows very little variation throughout the year. The relative humidity is up to 56% and usually higher in summer than in the winter owing to the prevalence of ocean and hence moisture laden wind blowing across Niger State from March to October(Nweke, 1988). The soils and the vegetation of the communities occupy an important position in her development. The soils in the state were derived from

The hydromorphic and organic soils developed on alluvial and fluvial deposits of variable texture, notable along the river flood plains, and

The ferrasols, developed especially on sedimentary rocks.

Methodology.

The data used were collected from practical exercise of field study carried out which was stretch from 7.00am to 7.00pm each day within the selected areas of the town 90 people of different ages, sexes and weights were interviewed through the questionnaire to show their thermal sensation with the environment.

Dry bulb (Td) and wet bulb (Tw) temperatures measured in degrees Celsius were used for the temperature of the selected areas. A widely used measure of comfort of thermal sensation, probably the most commonly employed for determining thermal sensation is the effective temperature (ET) index which is calculated from an empirical formula.

$$ET = 0.4\,(Td + Tw) + 4.8 \text{ --- } (i)$$

Where Td and Tw are dry and wet bulb temperature respectively in oC. The resulting values are related to a subjective scale on sensation of people within the areas covered.

Another measure of comfort in relative strain index (RSI) which was devised by Lee and Herschel (1966) was to account for insulating effects of the body. The fomular for relative strain index is given as:

$$RSI = \frac{10.7+0.7(Ta - 35)}{44 - ea} \text{ ---- } (ii)$$

Where Ta is the dry bulb temperature and ea is the vapour pressure of the air. The vapour pressure VP is calculated thus:

$$VP = \frac{RH \times SVP}{100} \text{ ---------- } (iii)$$

Where RH is the Relative humidity (%) and SVP is the saturated vapour pressure For a healthy person, the scale of sensation indicates comfortability conditions for the people when RSI is less than 0.2, discomfortable conditions when RS is more than 0.3, distress conditions when RS is more than 0.4 and complete failure when RS is more than 0.5 Hobbs (1980) stated that when body temperature exceeds 400C and ET is above 330C with RS of 0.3, a critical point of discomfortability is observed.

Results and Discussion

Equations (i) and (ii) were computed and analyzed in the diagrams below for the six selected areas in the town, which were

representatives of measures to examine the relationships between human health and comfort, and the physiological climatic environment. These areas include (i) Bosso (ii) Gidan Kwano (iii) Chanchaga (iv) Bosso Low Cost area (v) Tunga (vi) Kpakungu.

As can be noted from the table and the diagrams in figure 2.0, both the ET and RS values indicate that conditions were uncomfortable for most parts of the area during the periods most especially between the hours of 1.00 pm and 4.00 pm, these periods are characterized by physiological stresses and discomfort.

The ET values varied between approximately 270C and 290C over Bosso area, 260C and 290C at Gidan Kwano area, 270C and 290C at Tunga area, Chanchaga was 260C and 280C, Bosso low cost between 270C and 300C and Kpankungu is between 27.60C. and 290C.Generally, the relative high values occur visually in all the locations reflecting the significance of transportation pollution and poor waste disposal system, other contributing factors as observed from this research finding are the levels of human activities, poor ventilation of the buildings and overcrowding of human population. For example, at Kpakungu area with high population density and bus stop for both intra and inter-urban traffic movement reflect the significance of transportation within the area.

The impacts of the aforementioned factors also reflect on the temperature of the selected areas. For example the Td temperature of chanchaga range between 260C and 280C all is reflecting the high rate of temperature in the areas.

The relative strain index values (RSI) show greater contrasting condition over the selected areas than the ET values. Over Bosso area the RS values varied between 0.1 and 0.7 at Bosso low cost area between 0.1 and 0.6 , Tunga area between 0.2 and 0.5 indicating a relative high values. The low values were experienced at Chanchaga and Gidan Kwano which is the out sketch of the town with less concentration of human population and activities, compared with Kpakungu and Bosso areas.

The terms of thermal sensation with the use of ET scale, the ET diagram indicated that none of the areas selected was thermally comfortable during the study period and people were exposed to physiological stresses and discomfort especially during the day.

Based on the subjective reactions of the people interviewed, it appears that the RS index gives a more accurate assessment of the sensation during the study period. The afternoon and evening periods were relatively cool and comfortable for most people and generally uncomfortable conditions which occurred over most part of the town for example Chanchaga and part of Gidan Kwano areas as indicated by RS value reflect that the effects of the geographical locations located at the outsketch of the town occupied by modern houses with good ventilation system and less population density within the area.

From the RS values, Kpakungu area and part of Bosso which are important bus stops with high population concentration provide the "heat islands" of the town which relatively open spaces such as the outsketch of Gidan- Kwano and chanchaga areas provide the 'Cool Spots'. Thus in relative terms the influence of transportation pollution, population concentration, urban waste generation and adjusted and arrangement of the buildings provide the major factors between the heat islands and the cool spots in town.

Observatory Areas within Federal University of Technology, Minna.

Table 1.0 FUT Bosso Campus

Time	
Td (oC)	
Tw(oC)	
RH (%)	

VP(mb)
ET
RS

7.00	28.0	26.5	87	32.5	26.6	0.1
8.00	28.0	26.5	87	32.5	26.6	0.1
9.00	28.5	26.0	81	31.2	26.6	0.2
10.00	28.5	26.0	81	31.5	26.6	0.2
11.00	29.0	27.0	84	33.49	27.2	0.3
12.00	30.0	27.0	81	34.37	27.6	0.4
1.00	30.0	27.5	81	34.32	27.6	0.4
2.00	31.0	27.5	78	35.24	27.8	0.6
3.00	32.0	27.5	78	36.48	28.6	0.7
4.00	30.0	26.5	73	31.00	27.2	0.3
5.00	28.5	26.5	81	31.15	26.8	0.2
6.00	28.5	26.0	83	31.01	26.4	0.2
7.00	28.0	26.5	87.	33.46	26.6	0.1

Table 2.0 Gidan Kwano

Time	Td (oC)	Tw(oC)	RH (%)	VP(mb)	ET	RS
7.00	30.0	27.5	81	34.37	27.8	0.3
8.00	30.0	27.0	81	34.37	27.6	0.3
9.00	30.0	27.0	81	34.37	27.6	0.4
10.00	30.5	27.5	74	35.57	28.0	0.4
11.00	31.0	27.0	71	33.43	28.0	0.4
12.00	31.5	27.0	71	33.19	28.2	0.4
1.00	31.5	27.0	71	35.59	28.2	0.4
2.00	32.0	28.0	68	33.83	29.2	0.5
3.00	33.0	28.0	71	34.14	28.2	0.5
4.00	32.0	27.5	74	34.60	28.6	0.5
5.00	31.5	27.5	81	36.60	28.4	0.5
6.00	30.0	28.0	81	34.60	28.4	0.5
7.00	30.0	27.5	81	34.37	27.8	0.3

Table 3.0 Tunga area

Time	Td (°C)	Tw(°C)	RH (%)	VP(mb)	ET	RS
7.00	28.5	26.0	81	31.15	26.6	0.2
8.00	29.0	26.0	81	32.25	26.6	0.2
9.00	29.0	27.0	84	33.49	27.2	0.3
10.00	30.0	26.0	73	31.00	27.2	0.3
11.00	30.0	26.0	73	31.00	27.2	0.3
12.00	30.5	26.5	74	32.49	27.6	0.4
1.00	31.0	27.0	71	33.43	28.0	0.4
2.00	31.5	27.0	71	33.59	28.2	0.4
3.00	32.0	28.0	68	33.83	29.2	0.5
4.00	32.0	27.5	74	34.60	28.6	0.5
5.00	30.0	27.5	81	34.37	27.8	0.4
6.00	29.0	27.0	84	33.48	27.2	0.3
7.00	28.5	26.5	81	32.25	26.8	0.2

Table 4.0 Chanchaga area

Time	Td (°C)	Tw(°C)	RH (%)	VP(mb)	ET	RS
7.00	28.9	26.5	83.4	32.97	27.0	0.2
8.00	29.0	26.4	82.4	32.94	26.96	0.3
9.00	29.3	26.6	81.6	32.73	27.16	0.3
10.00	29.7	26.6	77.6	33.06	27.28	0.4
11.00	30.0	26.9	78.2	33.39	27.88	0.5
12.00	30.7	27.0	74.8	34.6	28.00	0.5
1.00	31.0	27.1	74.4	34.36	28.4	0.5
2.00	31.5	27.4	72.6	34.04	28.18	0.5
3.00	32.2	27.8	71.2	34.28	28.68	0.6
4.00	31.2	27.1	73.2	33.6	28.40	0.5
5.00	30.1	26.6	77.2	32.25	27.48	0.4
6.00	29.4	26.6	80.8	33.20	27.24	0.3
7.00	29.2	26.6	81.6	33.20	27.12	0.3

Table 5.0 Bosso Low-cost area

Time	Td (°C)	Tw(°C)	RH (%)	VP(mb)	ET	RS
7.00	28	25.5	81	32.5	26.2	0.1
8.00	28	25.4	81	32.5	26.6	0.1
9.00	28.5	26.4	81	32.3	26.8	0.2
10.00	28.5	26.0	84	32.15	26.6	0.2
11.00	29.0	26.0	81	32.25	26.8	0.2
12.00	30.0	26.6	81	36.69	27.4	0.6
1.00	31.0	27.0	77	35.24	28.0	0.6
2.00	31.0	27.0	78	35.24	28.0	0.6
3.00	31.5	27.5	78	34.6	28.4	0.6
4.00	31.0	26.0	74	33.6	28.2	0.5
5.00	29.0	26.5	74	32.25	26.8	0.2
6.00	29.5	26.5	81	33.2	27.2	0.3
7.00	29.5	26.5	81	33.2	27.2	0.3

Table 6.0 Kpakungu area

Time	Td (°C)	Tw(°C)	RH (%)	VP(mb)	ET	RS
7.00	28.9	26.5	83.4	32.97	27.00	0.2
8.00	29.0	26.4	82.4	32.94	26.96	0.3
9.00	29.3	26.6	81.6	32.73	27.16	0.3
10.00	29.7	26.6	77.6	33.06	27.28	0.4
11.00	30.0	26.9	78.2	33.39	27.88	0.5
12.00	30.7	27.0	74.8	34.60	28.00	0.5
1.00	31.0	27.1	74.4	34.36	28.04	0.5
2.00	31.5	27.4	72.6	34.04	28.18	0.5
3.00	32.2	27.8	71.2	34.28	28.68	0.6
4.00	31.2	27.1	73.2	33.78	28.40	0.5
5.00	30.1	26.6	77.2	32.71	27.48	0.4
6.00	29.4	26.6	80.8	32.83	27.24	0.3
7.00	29.2	26.6	81.6	33.05	27.12	0.3

Conclusion

This study has been able to look into how climate parameters affect human being in an environment. The behavior of different climate parameters like temperature Td, Tw and ET and relative humidity (RH) in relation to time of the day was clearly demonstrated However, the influence of these parameters on the orientation of buildings, human activities, ventilation and general housing conditions were able to reveal the comfort level of human population in an environment. These equally provide the significance between the heat islands and cool spots in an environment.

Generally, temperature were high during the period of studies .Dry bulb temperature (Td) ranges between 28°C 32 °C and wet bulb (Tw) range between 25.5°C and 28°C respectively in all the six selected areas but judged from a subjective reactions of people interviwed, the RSI values give a more accurate assessment of the level of comfortability of the people during the period of study. The minimum RSI value of 0.1 was observed in Bosso Low cost.

In summary, this reveals the fact that micro-climatic parameters like temperature, humidity and winds are more important in determining comfort level of individuals in urban environment as indicated in the selected areas of Minna.Other related factors such as human activities resulting to pollution and waste disposal problems, and orientation of buildings are significant factors.

A more significant aspect of the study in that it can be used to provide information for proper re-designing of urban expansion and renewal, thus the influence of heat load within an urban environment must be a greater concern of city planners as there is very little emphasis placed on the need to reduce head loads to a comfortable level in planning or re-designing of old cities mostly in Africa in general and Nigeria in particular.

References.

Ayoade J.O. (1988): Introduction to climatology for the Tropics, Ibadan spectrum Bks Ltd.

Hill B.C. (1993) : Climate change and health in the tropics, who will be most Vulnerable, Ibadan spectrum Pg 35-43

Houghton A.S. (1993): "General climatology" 3rd Edition, prentice-Hall Inc. New Jersey PP 347-356.

Hobbs J.E (1980): "Applied climatology" A study of Atmospheric Resources. Butterworth, London Pg 62-73.

Lafleur A. H. (1991): Global climate change: the potential effects on health. *BMJ* 1997; 315:805-9.

Landsberg, H.E. (1990): "The assessment of Human Bioclimate: A review" Typescript of a manuscript prepared for publication by WMO and Cited by Lafleur (1991).

Lee A.R. and Herschel B.M. (1966): Microclimatic parameters affecting corn Yield in India, JAM 1970; Pg 34-45.

Nweke, J.O. (1988): Malaria and climate: sensitivity of malaria potential transmission to climate. *Ambio* 1995; 24:200-7.

Ojo, O. (1977): Man's physical Environment. Heinemann Pp 38-40.

Wahab B. (1995): Indigenous knowledge system and the human settlements: Towards integration into Education curriculum "University Press, Dec. 1995.