COMPARATIVE ANALYSIS OF TEMPERATURE AND RELATIVE HUMIDITY IN RURAL AND URBAN SETTING OF KADUNA STATE, NIGERIA

BY

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ABSTRACT

This study compared Temperature and Relative Humidity between Urban core (Central Business District) of Kaduna Metropolis and a Rural Control station cited in a suburb of Kaduna town (Goni Gora). Temperature/Relative Humidity USB data loggers were used for data acquisition for one month. A total of 8064 temperature and relative humidity values were collected each and summarized to 672 by finding hourly mean. 1hour mean temperature and relative humidity values for urban core and control station were subjected to student "t" test to determine if there is significant difference in temperature and relative humidity between the two sampled sites. The "t" test results showed a significant difference in both temperature and relative humidity between the urban core and the control station at 0.05 statistical significance level. The highest temperature value recorded in the urban core was 33°C and the lowest value was 20.5°C. The rural control station had a high temperature value of 35°C and a lowest value of 19°C. The relative humidity values exceeded 100% many times in the urban core. In the control station, there was no time a relative humidity value greater than 100% was recorded. The study observed that the urban core is warmer and more humid than the rural surrounding. This study recommends proper urban planning, through creation of open spaces and green areas as a way of improving the livability of the urban area through increased heat circulation and absorption.

Key words: Kaduna State, Relative humidity, Rural setting, Temperature, Urban setting

INTRODUCTION

Urban climates all over the world are distinguished from those of less built-up areas by differences of air temperature, humidity, wind speed and direction, and amount of precipitation. These differences are attributable in large part to the altering of the natural terrain through the construction of artificial structures and surfaces. For example, tall buildings, paved streets, and parking lots affect wind flow, precipitation runoff, and the energy balance of an urban environment (Chan, 2001).

The atmosphere over urban centres is characterized by substantially higher concentrations level of pollutants such as carbon monoxide, the oxides of Sulfur and Nitrogen, Hydrocarbons, Oxidants, and particulate matter. Foreign matter of this kind is introduced into the air by industrial processes (for example, chemical discharges by oil refineries), fuel combustion (for the operation of motor vehicles and for the heating of offices and factories), and the burning of solid wastes. These pollutants contribute to a greater extent and the characteristic of urban microclimate (Colls, 2002). Globally, urban environments are generally found to be warmer than their rural surrounding, due to the altering effects of the natural structures in the urban environment by man (Idzikowska, 2010). Most cities in Turkey are 14% warmer than their counterpart rural environments (Sümer and Demir, 2002). According to Gulyas, Matzarakis and Unger (2007), the concentration of tall buildings and high population density are responsible for the rapid changes in thermal comfort in most cities of Hungary. Most cities in Sub-Saharan Africa have warmer microclimatic conditions due to high amount of insolation received and emission of pollutants (Linden, Thorsson, and Eliasson, 2008).

The rate of urbanization in Kaduna Metropolis is observed to be in high rate over the last 15 years. A lot of structures have been erected, some undergoing construction. Most of the structures being constructed have no enough space for air circulation, and most house owners do not make provision for green areas. Moreover, the central business district (CBD) is concentrated with illegal structures, with few or no provision for green space and air circulation (Sani, 2012). According to Ariko, Sawa and Abdulhamed (2014) assertion, the rural environment of Kaduna Metropolis have different wind characteristic compared to its urban counterpart. Since wind characteristics of an area have influence on heat circulation pattern (Abdulhamed, 2011), this study therefore, aims at a comparative analysis of temperature and relative humidity in rural and urban setting of Kaduna State, Nigeria. The objective of the study is to examine temperature and relative humidity differences between urban core and rural surrounding of Kaduna Metropolis.

THE STUDY AREA

Kaduna is the State capital of Kaduna State in north-Western Nigeria. The area is located between Latitudes 10° 23'-10° 43'N and Longitudes 7° 17'-7° 37'E (see Fig.1), comprising of Kaduna north Local Government, Kaduna south Local Government, southern part of Igabi Local Government, and the northern part of Chikun Local Government. Kaduna is 912 km north of Gulf of Guinea, about 390 km from Nigeria's northern border and 180 km from Abuja, the country's capital city. It has an area of about 35 square kilometers (Sani, 2012; Ariko, Sawa and Abdulhamed, 2014).

The city has tropical continental climate type characterized by wet and dry season. The tropical continental is more pronounced in the dry season particularly in December and January. The dry season is dominated by the north-east trade wind called Harmattan which prevails from November to February. The dry season is also rainless from October to April. The wet season is dominated by the south-east winds which start between May/June to October (Ayoade, 1988). The natural vegetation of the study area is that of the Northern Guinea Savannah with grass dominating and scattered trees hardly higher than 15ft with broad leaves. Meanwhile, the seasonal character of rainfall in the study area has influenced the vegetation which turns evergreen during the wet season and pale brown in the dry season respectively (Oguntoyinbo, 1983).

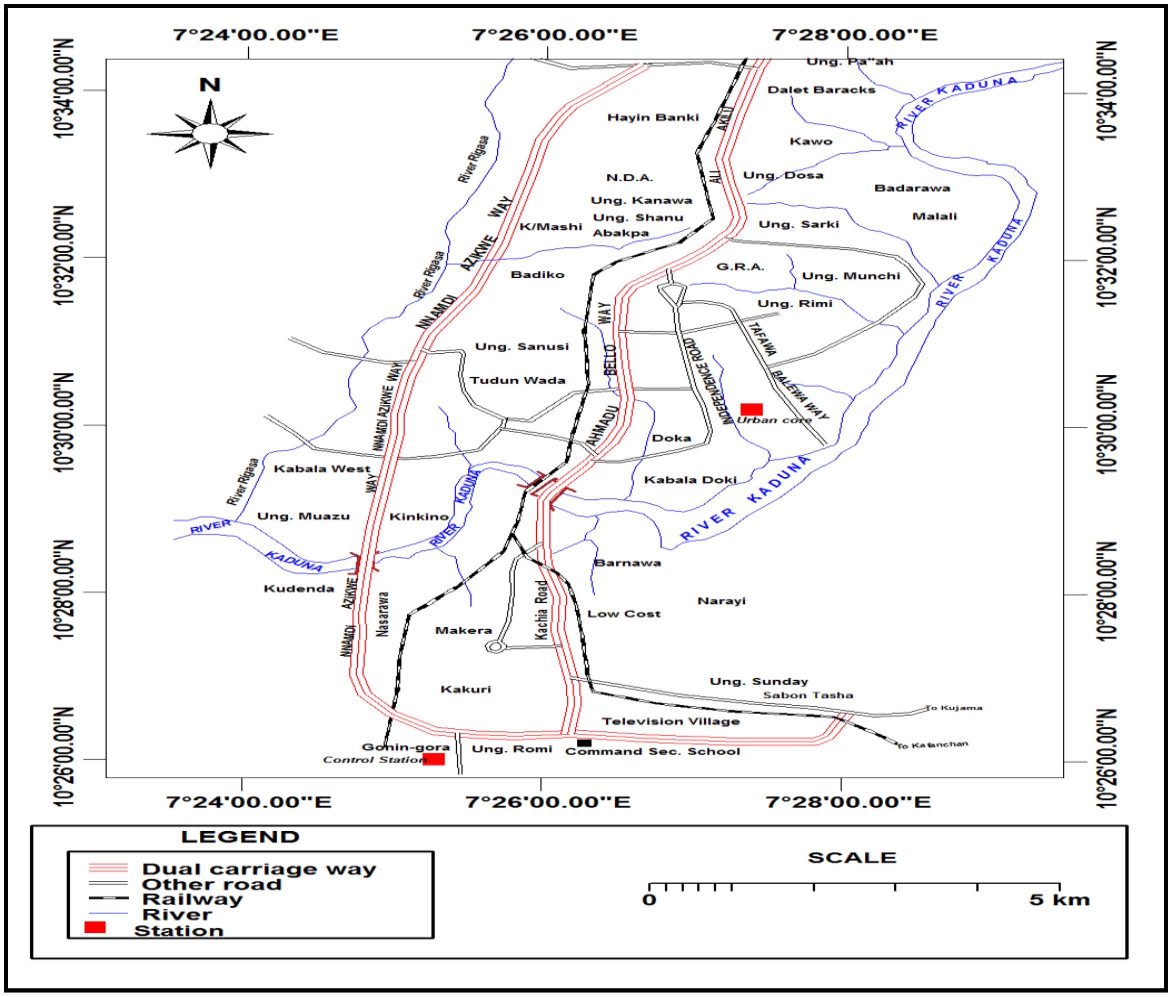

Fig. 1: Kaduna Metropolis
Source: Kaduna State Environmental Protection Authority

MATERIALS AND METHODS

This study was based on Urban-rural comparison approach. The sites selections for this study were based on Local Climatic Zones (LCZ) categorization by Steward and Oke (2009) and are in accordance with World Meteorological Organization standard (i.e. to represent the zones where the data were collected). The sites that best represent the Local Climatic Zones (LCZ) category for urban core and a control station were selected.

The data used were temperature and relative humidity and were measured and recorded by digital USB- Temperature/Relative humidity data loggers which were mounted in the Urban core and Rural control stations (rural environment), for a period of one month (from 12th June, to 9th of July, 2015). The data were collected at this time of the year (summer) by assumption that the atmosphere has less durst. A total of 864 temperature and relative humidity values were measured and recorded, which were downloaded from the data loggers to the computer. The 8064 data were summarized into 672 mean hourly values for further analysis. A 't' test was conducted to test differences in temperature and relative humidity between the urban core and rural control station is statistically significant at 0.05 significant level.

RESULTS AND DISCUSSION

From Fig. 2, it can be observed that the temperature is characterized by regular rising and falling on a daily bases. The highest temperature recorded in this area was 33°C and the lowest was 20.5°C, with a monthly range of 12.5°C. The highest temperature values were recorded between 12:00 and 15:00 daily; while the lowest values were recorded between 00:00 and 05:00 daily (see Fig. 2). From Fig. 2, it can be deduced that afternoon periods are the hot periods in the urban core. This is a clear indication that the major source of air warming is the solar radiation, since the high temperature is recorded in the afternoon hours of the day, with low temperature during the night.

Throughout the sampling period, there was no record of temperature value that exceeds the thermal stress warning level (50°C). Temperature characteristics are a typical characteristic of a Tropical humid environment. The record is not far from what Abdulhamed (2011), recorded in wet season in Kano.

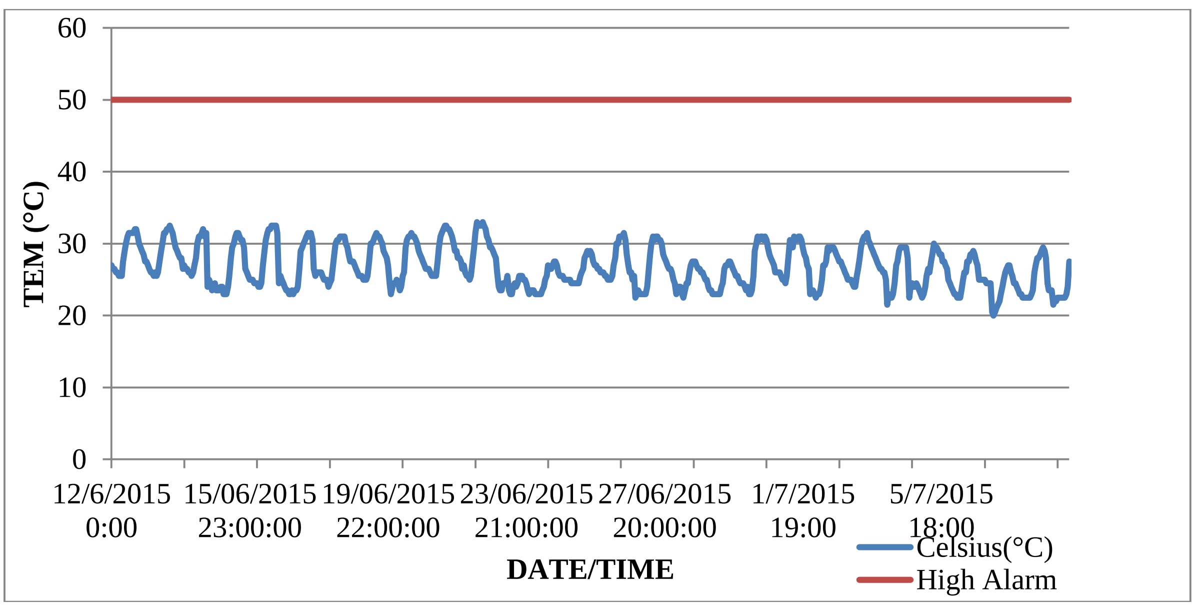

Fig. 2 Temperature Trend in the Urban Core

The Relative humidity record shown in Fig. 3 is characterized by rising and falling. The Relative humidity values exceeded 80% alarm level throughout the study period. This shows that the area is a Tropical humid environment as classified by Ayoade (1978). The effect of climate change on the environment has not significantly change the humid characteristic of this area. This is because the Relative humidity of the area is not far from Ayoade's (1978) statistic.

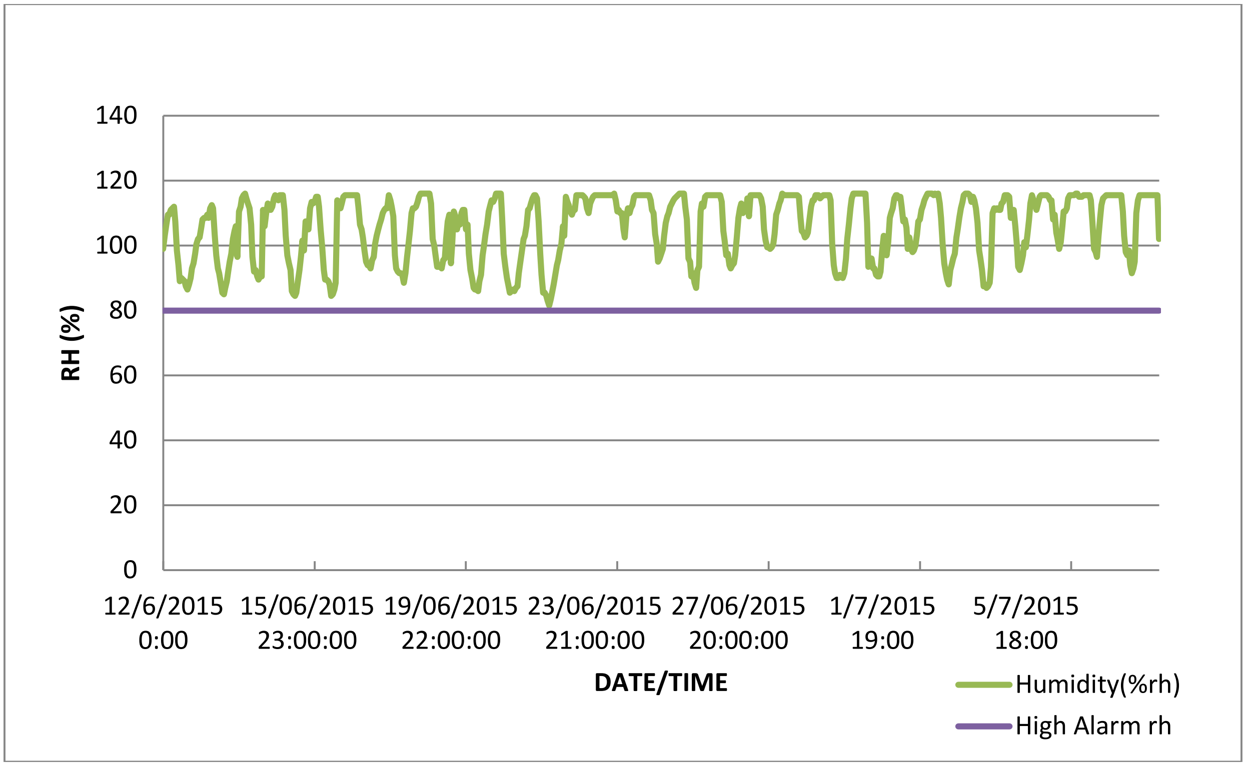

Fig.3 Relative Humidity Trend in the Urban Core

From Fig.4 it can be deduced that the temperature pattern at the control station is cyclical in nature. There are periods of the day that the temperature values are high, while other periods of the day are characterized by lower temperature values. Though the Control station occasionally recorded some very high temperature values of up to 35°C at about 12:00 noon to 14:00pm, lower values were predominant throughout the study period. This high temperature record was due to the vegetal characteristic of the area, which allows quick heating of the air within the Control station. The high temperature alarm value (50°C) was not recorded; therefore, the graph analyzer did not record and plot the high temperature alarm line.

This is a clear indication that the only major source of heat at the control station is the solar radiation. Unlike the Urban core there seem to be a rapid drop in temperature, after the peak period. The temperature range at the control station is 14.5°C (33.5°C-19°C); this value is higher than the range at the urban core. This implies that the urban core is often warmer than the Control station which is 10.5°C. This wide difference may not be far from the nature of the structures and surfaces found in the urban centre, which affect wind flow. The tall buildings, densely populated, traffic load must have affected the urban meteorological characteristics.

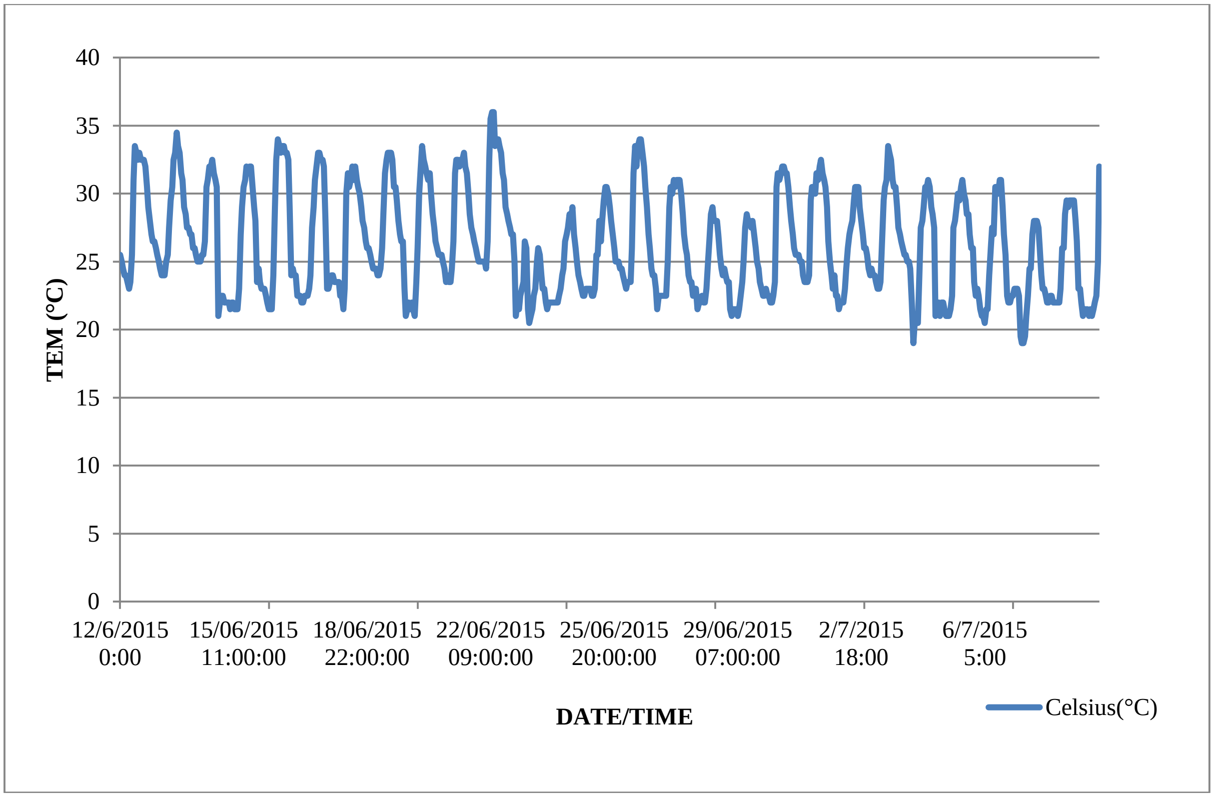

Fig.4 Temperature Trend in the Control Station

The Relative humidity pattern at the Control station exhibited a high temporal variability, though not like the urban core. Like the Urban core, the Relative humidity shows a cyclical pattern, with values that exceeded 80% high alarm relative humidity level. Most time, high temperature periods are associated with lower values of Relative humidity. According to Yilmaz and Toy (2007), the different in Relative humidity between Urban areas and there corresponding country sides is the windless nature of the urban centers. Kaduna Metropolis is therefore, not an exception. However, though the control station did recorded Relative humidity values that exceeded the alarm level for Bioclimatic conditions many times, the values that fell below the alarm level were predominant throughout sampling period.

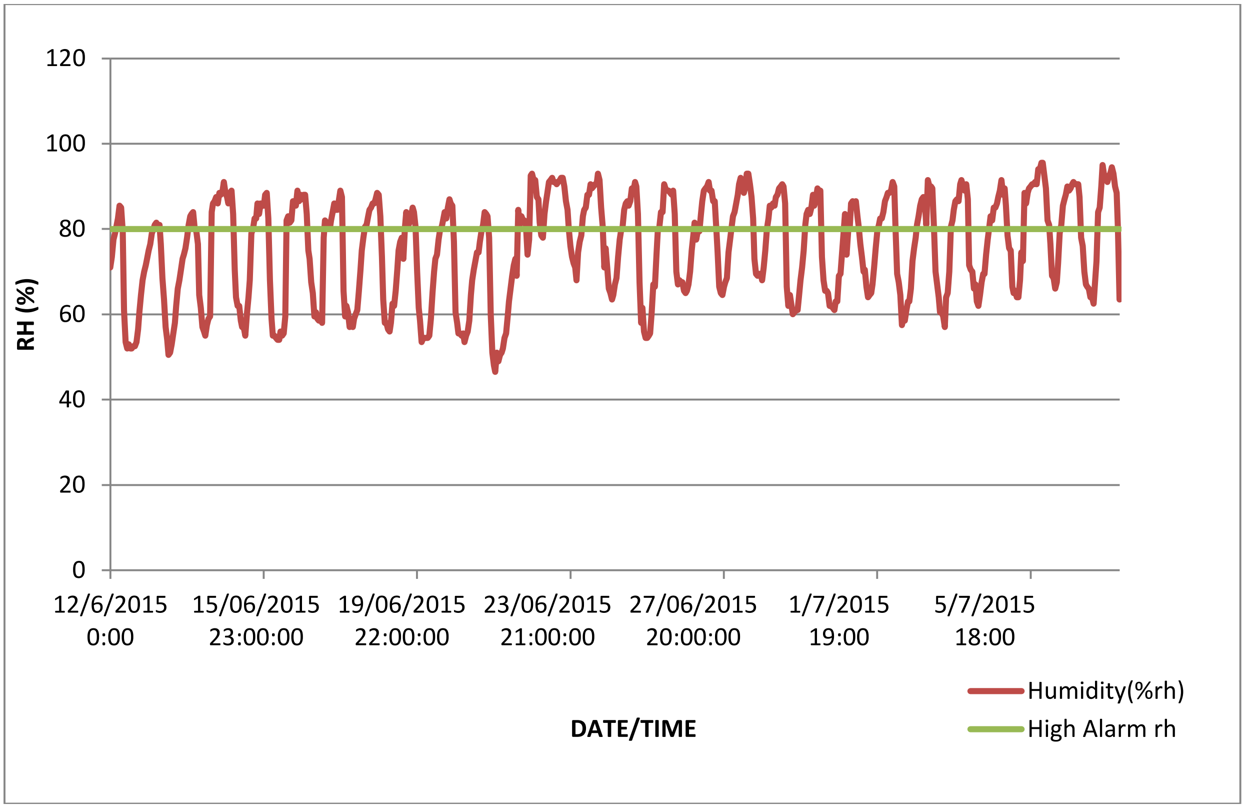

Fig. 5 Relative Humidity Trend in the Control Station

Tables 1 and 2 show the t-test results that test for significance difference in temperature and relative humidity between the urban core and rural control stations.

Table 1: t-test Result for Temperature Difference between the Urban Core and Rural Control Station

Location	N	Mean	S.D	Mean dif.	Observed t-value	Critical-t	D.f	Sig. level
Urban Core	659	27.52	2.13	3.32	15.72	2.256	1361	0.05
Rural Control Station	659	24.20	2.60	3.32				

Table 1 shows that the observed 't'=15.72 is greater than critical 't'=2.256. This shows that there is a significant difference in temperature values between the urban core and the rural areas environments. This difference may be attributed largely to space and structural characteristics differential between the urban and the rural environments. The urban environment is characterized by tall buildings, pavements, impervious surfaces among others; these alter the micro-climate of the urban areas. The difference in mean temperature between the urban core and rural control station is 3.32°C; this value is not negligible and is significant enough to create a variation in the bioclimatic conditions between the urban environment and the rural surrounding. This result corroborates the findings of Liu, You and Dou (2009) observed in their research on Urban-rural humidity and temperature differences in Beijing. Their result shows that Beijing is 3°C warmer that its rural surrounding and attributed the difference to variation in canyon geometry of the city. Though the conditions may not be the same, but urban environment seem to be warmer than the rural surrounding.

Table 2: t-test Result for Relative Humidity Difference between the Urban Core and Rural Control Station.

Location	N	Mean	S.D	Mean dif.	Observed t-value	Critical-t	D.f	Sig. level
Urban Core	659	105.97	9.860	30.316	49.890	2.256	1361	0.05
Rural Control Station	659	75.65	12.088	30.316				

Table 2 shows that the observed ‘t’=49.890 is greater than critical ‘t’=2.256. This an indication that there is a significant difference in Relative humidity condition between the urban core and the rural environment of Kaduna metropolis. The mean value of Relative humidity (RH) in urban core is 105.97, while the rural control station has 75.65. This indicates that the urban environment is more humid than the rural counterpart. The standard deviation (SD) of the Relative humidity in the urban core is 9.86, while the rural environment has a value of 12.088. This is also indication that there is high temporal variability in relative humidity in the rural environment, whereas the urban core is constantly humid. This result confirmed the assertion of Liu, You and Dou (2009) in their research on Urban-rural humidity and temperature differences in Beijing; urban areas because of the concentration of pollutants and poor air circulation seem to have higher air relative humidity than the rural surrounding.

CONCLUSION

From the results of this study, it can be concluded that there is a significance difference in both temperature and relative humidity between the urban core and the rural control station. Both temperature and relative humidity in urban areas were widely affected by the different anthropogenic features of the area. In other words, the urban core is relatively warmer and more humid than the rural surrounding, thereby having negative impacts on the livability of the Urban dwellers. In an attempt to proffer solutions to the problems, it is recommended that urban planners and other relevant agencies should employ policies that will encourage decongestion of the congested parts of major cities. This will allow free movement of air, and rapid heat circulation. This will in turn increase the livability of the urban centers.

Also, there is the need for policies and laws that will encourage green areas in urban centers through re-forestation. This will help in heat reduction via two mechanisms: by shading surface and adding moisture to atmosphere through evapotranspiration. The results and findings of this research and others should not be considered as mere academic exercise, but should be used when designing new cities and the revalidation of the old ones. Finally, more studies can still be carried out in this area, such as assessing the seasonal variability in temperature and relative humidity.

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