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The Intensity and Extent of Thermal Discomfort in Lokoja, Nigeria

by

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Abstract

The degree and coverage of thermal discomfort among the residents of Lokoja, Nigeria were analysed. Data on climatic elements such as temperature, and relative humidity were sourced from the archive of Nigerian Meteorological Agency (NiMet). Statistical tools like Thom's Discomfort Index and the Humidex Calculator were used. The results showed that the degree of thermal discomfort in Lokoja varied between "noticeable discomfort" and "evident discomfort". The percentage of residents of Lokoja affected by thermal discomfort varied from under 50% to over 50%. This means other extreme forms of thermal discomfort like "intense", "dangerous" and coverage such as everybody feeling stressed or state of medical emergency were not experienced in the town. Various measures that could be put in place and used to ameliorate and mitigate the thermal discomfort that prevail in Lokoja were also recommended in the study.

Keywords: Thermal Discomfort, Urban Heat Island, Thom's Discomfort Index, The Humidex Calculator.

1. Introduction

Human beings engage in various activities; some of these activities such as manufacturing industries, construction, manure management, energy industries, metal production, rice cultivation, field burning of agricultural residues, wastewater handling, waste incineration (UNFCCC,2013) along with increase in population have resulted in increase in the amount of Green House Gases (GHG) in the atmosphere leading to green house effects, global warming and climate change. A major product of these climate change, global warming and urbanization is Urban Heat Island (UHI). UHI can be defined as a settlement of warmer air temperature as compared to the temperature of the suburb or countryside (Aremu, 2014). This high temperature causes thermal or heat discomfort. Thermal comfort is a condition of the mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE Standard 55, 2010). Thermal or heat discomfort on the other hand is a situation where the environment (including ambient or air temperature along with the relative humidity) of a settlement

becomes harsh or unbearable to its residents. The urban heat island phenomenon has close correlation with thermal comfort or discomfort. Several factors come together resulting in the occurrence of thermal discomfort in urban settlements. These factors are sometimes grouped together into environmental factors. The environmental factors are sometimes known as physical or natural factors and include climatic and weather elements such as air temperature, mean radiant temperature of the walls of the room, relative humidity, relative air speed, atmospheric pressure, light intensity as well as noise level. Apart from environmental factors, other factors responsible for thermal comfort or discomfort in a settlement are grouped together under the heading man-made or anthropogenic factors. They may also be referred to as external or personal parameters. They include the level of human activities and social conditions, the type of clothing, age and sex (Gheorghe, 2013). They are factors that may not have initiated the thermal discomfort, but may have likely made it worse. These factors are likely to make urban heat worse in a settlement. Some of these factors are bush burning, cutting down of trees, deforestation, industrial and agricultural activities, construction of buildings and roads (Gheorghe, 2013) .

2. Review of Related Literature

The parameters mentioned above may come together to make the environment harsh and unbearable for human beings. This makes people especially in such settlements or environment to be predisposed to higher risk of morbidity and mortality. It even results in diseases of various kinds like skin rashes, measles, meningitis, heat exhaustion, stroke, e.t.c and loss of working hours (Nastos and Matzarakis, 2006). Worldwide various thermal discomfort indices have been used taking into consideration air temperature, relative humidity, wind speed and so many other factors (Thom, 1959; Steadman, 1971; Matzarakis and Mayer, 1996; ISO 7730, 1983; Becker Potchter and Yaakov, 2003). In Lokoja, several studies have been carried out about increasing temperature and urban heat effect using various methods, but very little on thermal discomfort (See Ifatimehin, 2007 ; Ifatimehin and Adeyemi, 2008 ; Ifatimehin. Ujoh and Magaji, 2009; Ifatimehin, Ishaya and Fanan, 2010; Alabi, 2012; Audu, 2012; Ifatimehin, Adeyemi, and Saliu, 2013). Infact, none has utilized two inferential methods to investigate the extent and the degree to which heat discomfort has been affecting the residents of Lokoja. This gap in knowledge is what this work set out to fill.

The Thom's discomfort index and the Humidex are some of the most popular and widely used in the world to ascertain the coverage and degree of discomfort, although the Humidex being more so in Canada. They are based on temperature and relative humidity/vapour pressure. The aim of this article, therefore, was to study thermal discomfort using the two indices mentioned above, while the specific objective involves the analyses of the intensity and extent of thermal discomfort in Lokoja.

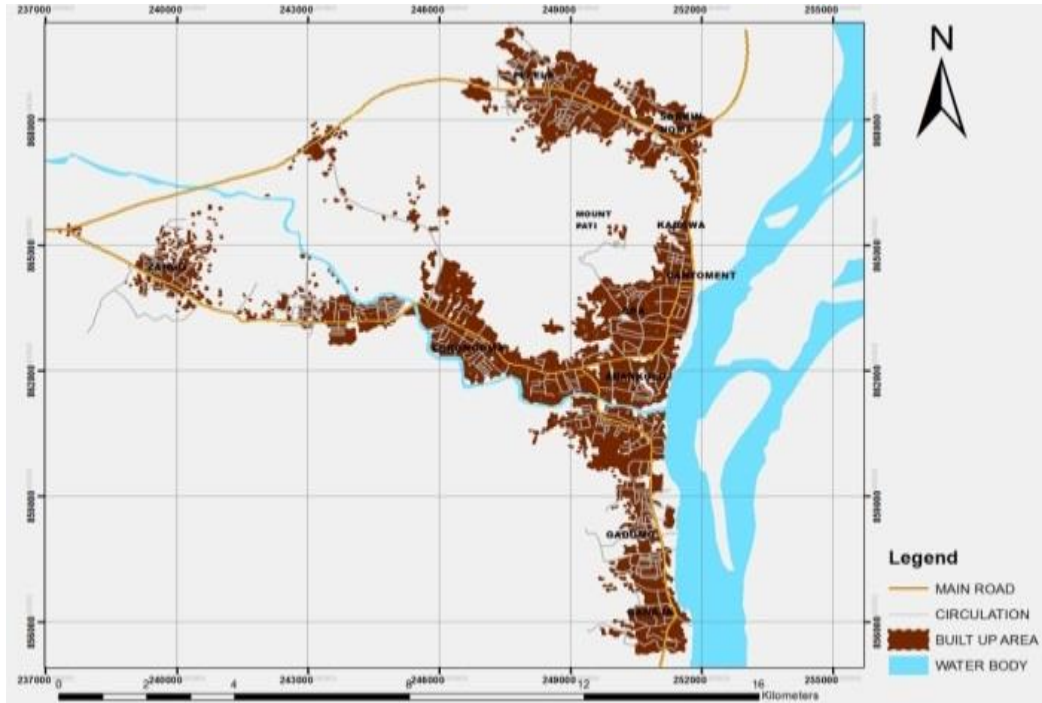
3. Study Area

Lokoja (Fig. 1) the study area is an urban settlement. It is made up of small sized settlements together with the old Lokoja town (Alaci and Chup, 2015) . Therefore, Lokoja town is presently made up of the wards that constitute the original Lokoja (Karaworo, Kpata, cantonment, Kabawa and new layout) and some settlements that were originally separate and independent from it. Some of these include Adankolo, Lokongoma, Felele, Otokiti, Ganaja (Alaci and Chup, 2015). Lokoja is located between latitudes $7^{\circ} 45' N$ - $7^{\circ} 51' N$ of the equator and Longitudes $6^{\circ} 41' E$ – $6^{\circ} 45' E$ of the prime meridian. It is the administrative and commercial capital of Kogi State as well as the headquarters of Lokoja

Local Government Area. As at 2009, its estimated population was 127, 139 people (Lokoja Master Plan, 2009). It is a settlement located close to several physical features. The most important ones being Mount Patti, Rivers Niger and Benue (Fig: 1). It is located in Koppen's climatic zone of Aw with wet and dry seasons and total annual rainfall that varies between 804.5 mm – 1767.1mm (Ifatimehin, Ujoh and Magaji, 2009). The rains begin in May and ends in October. It enjoys a maximum temperature of about 37.9⁰C that occurs between December and April. It has a mean annual temperature of about 27.7⁰ C and a relative humidity of about 30% during the harmattan or dry season and about 70% during the rainy or wet season (Audu, 2001). Lokoja has an average daily wind speed of about 89.9 km/hour while its average daily vapour pressure is about 26Hpa (Audu, 2001).

Lokoja's climatic characteristics puts it in guinea savanna zone that has been affected by human activities such as farming, cutting down of trees and bush burning resulting in derived savanna. However, there are presence of patches of gallery and savanna forests especially in areas close to rivers and streams. Lokoja also has an altitude that varies between 45 – 125 metres above sea level (Alabi, 2012) . The location of Lokoja as it relates to the physical features mentioned earlier results in limited land and densely packed buildings in several areas in Karaworo and Kabawa. This in association with the climatic characteristics mentioned above, climate change, global warming, increase in population and economic activities, high rate of urbanization, bush burning and deforestation have led to increase in temperature that inevitably results in urban heat island in Lokoja. This urban heat island is a very strong factor in the thermal discomfort being experienced in Lokoja (Alabi, 2012; Audu, 2012; Ifatimehin *et al*, 2013; Alaci and Chup, 2015;)

Fig 1: Lokoja and Its Built Up Areas



Source: Olatunde and Ukoje, 2016

4. Materials and Method

Average monthly temperature and average monthly relative humidity data (January to December) of Lokoja were gotten from the archives of Nigerian Meteorological Agency (NiMet). These data were used to determine the degree and coverage of thermal discomfort among the residents of Lokoja. The Thom’s Discomfort Index was used to determine the thermal discomfort coverage, with the formular being given as:

$$DI = T - (0.55 - 0.0055 RH) (T - 14.5)$$

Where,

DI = Discomfort Index

T = Average Monthly Temperature ($^{\circ}$ C)

RH = Relative Humidity of Air (%)

The accompanying discomfort index table is given in Table 1:

Table 1: Thom’s Discomfort Index Assessment

DI	Condition
≤ 21	No Discomfort
21 – 24	Under 50% of population feels discomfort
25 – 27	Over 50 % of population feels discomfort
28 – 29	Most of population suffers discomfort
30 – 32	Everyone feel stress
≤ 32	State of Medical Emergency

Source: Thom, 1959

Also, the Humidex calculator was used to determine the degree of discomfort among the residents of Lokoja. The formular for its calculation is:

$$H = T + (0.5555 \times (e - 10))$$

Where;

e = Vapour pressure (mb) and is calculated as;

$$e = (6.112 \times 10^A (7.5 \times T / (237.7 + T)) \times H / 100),$$

H = Humidex

T = Temperature ($^{\circ}$ C)

The interpretation of the various values derived using this formular was done with the humidex assessment table below.

Table 2: Assessment Scale of Humidex Degree of Comfort

Humidex ($^{\circ}$C)	Degree of comfort
20–29	No discomfort
30–39	Noticeable discomfort
40–45	Intense discomfort
46 – 53	Dangerous discomfort
Above 54	Heat stroke probable

Source: The Canadian Meteorologist, 1965

5. Results and Discussion

Analyses carried out using the Thom’s Discomfort Index indicated that over 50 % of the residents of Lokoja experienced heat discomfort in the months of February, April, May, June, July, September, October and December (Fig 2). This relatively large percentage (coverage) of Lokoja residents also experienced high degree of thermal discomfort as calculated by the humidex calculator (Fig 3). The humidex calculator showed that the thermal discomfort for these months apart from July and December were “Evident”. While in the months of July and December the thermal discomfort experienced by residents of Lokoja was “noticeable.” These situations are in agreement with the study carried out by Ifatimehin et al (2013)

The slight reduction in the intensity of heat discomfort in June and July was probably as a result of the rainy season being at its peak. The reduction in thermal discomfort experienced in December can be attributed to the Tropical continental (cT) wind (during the harmattan period). It being a cold wind assists in the reduction of ambient temperature during this period. Other months when residents of Lokoja experienced “noticeable” heat discomfort according to the humidex calculator includes January, March, August and November (Fig 3). In these months, Thom’s discomfort index showed that below 50% of the population experienced thermal discomfort (Fig. 2). The reduction in the percentage of residents that experienced discomfort may be attributed to low temperature due to the harmattan wind in November and January, while the gradual onset of the rainy season could be said to be responsible for the reduction in March, the reduction in August also being attributed to the rainy season.

Analyses using both Thom’s discomfort index and the humidex calculator revealed that there is no month that can be said to experience “ No discomfort” that is from January to December, residents of Lokoja experienced heat discomfort that varied between “noticeable” discomfort and “evident” discomfort. This means that other extreme and high degree of heat discomfort (humidex calculator) like “Intense”,

“Dangerous”, and “Probable Heat Stroke were not experienced in Lokoja. The Thom’s discomfort index also complimented this finding by indicating that there was no month that “most of the residents of Lokoja suffered discomfort”, “everyone feeling stressed” or there was a “state of medical emergency due to heat discomfort”

Fig 2: Thom’s Discomfort Values for Each Month of the Year

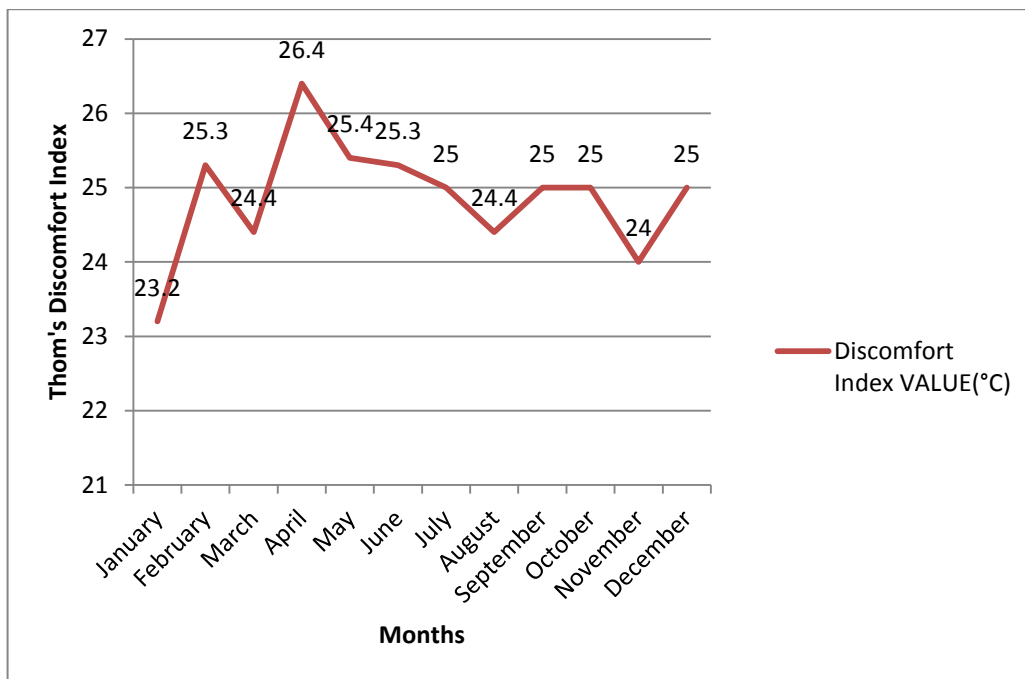
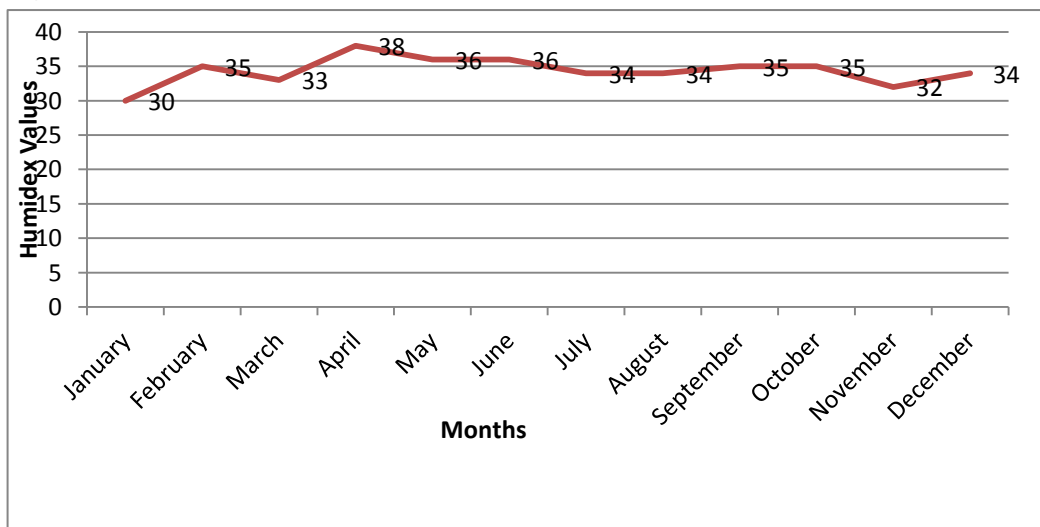


Fig 3: Humidex Values for Each Month of the Year



6. Conclusion and Recommendations

This study has shown that the residents of Lokoja experienced and suffered from thermal discomfort with the degree varying between noticeable discomfort and evident discomfort during different months in a year. Higher degrees of discomfort such as intense and dangerous were not experienced. Therefore, the perception and feeling of intense discomfort as often expressed by the people may be as a result of the contributory effects of other factors, for example, the putting on of dark coloured cloths by some of the residents. The low level discomfort experienced however, affect all areas of life and activities in Lokoja. For example, it has resulted in the occurrence of various diseases like skin rashes, measles, meningitis, heat stroke, heat exhaustion and even loss of working hours. Other consequences of heat discomfort experienced by residents included tiredness, weakness, dizziness and shortness of breath as well as general body disorder. The study also showed that the percentage of Lokoja residents affected by thermal discomfort varies from under 50% to over 50 % in different months in a year.

In order to reduce the harsh effects of thermal discomfort in Lokoja, the following measures should collectively be implemented where possible by individuals, communities and government.

- People should avoid putting on dark colour clothes that absorb high amount of heat.
- Residents of Lokoja should consume high amount of water especially during periods of heat discomfort so as to prevent dehydration. They should also reduce or avoid the consumption of intoxicating or caffeinated drinks during such periods.
- The cutting down of trees and deforestation should be discouraged especially during the construction of houses and roads. People should also be encouraged to make use of lawns instead of concrete paving in their houses. Extensive tree planting should also be encouraged.
- The high fences around houses should be discouraged. Its absence will allow for easy flow of wind. The directional flow of wind should be taken into consideration during the construction of houses.
- There is the urgent need to improve on the generation and distribution of electricity. This will enable the residents of Lokoja to make use of modern electrical and mechanical devices like fan, air-conditioner and fridge. Also, pipe borne water should be provided for residents of Lokoja, so that they can have enough for the amelioration of the effects of thermal discomfort.

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