Original Research Article

ESTIMATION OF BACKGROUND INDUCED TEMPERATURE IN AND AROUND BAKERY OVENS FOR SOME SELECTED LOCATIONS IN CALABAR

ABSTRACT

Estimation of bacground induced temperature from Bakery Ovens for Some Selected Locations in Calabar have been investigated. An in-situ measurement approach was adopted in order to quasi-accurately estimate temperature of Oven; wind speed in bakery and ambient temperature in bakery. The relationships between the measured parameters were obtained from plots of wind speed against Temperature and Temperature of oven against distance from Oven. Statistical correlations of wind speed values and temperature were estimated, which yielded a good positive correlation coefficient for wind speed and temperature in all cases and for all the six locations under study, with the relevant plots; these clearly show that all of the two parameters; wind speed and temperature are necessary to be used in analysing and assessing the wellbeing of workers in the perceived heat stressed environment. On the other hand, the coefficient of determination value shown on each of the correlation plots depicts that the models relating the Temperature and wind speed in each case respectively are good performing models. It was found out that the temperature exposure of workers in all the bakeries under study exceeded the WHO (20-29^{0}C) exposure limit for comfort. All the bakeries visited during this study all used firewood industrial oven.

Keywords; Heat; Oven; bakery; temperature estimation.

Introduction

Heat is recognized as a harmful physical factor in many workplaces. Thermal stress due to heat is caused by a number of internal and external thermal factors which lead to fatigue and development of disease in the human body. Environmental heat influences the performance and productivity of humans through changing physiological parameters, such as blood flow and hormone release rate. (Beheshti *et al.*, 2016)**.**

Heat exposure is a threat to performance, as well as to the health of *humans* who are working in heat related environment. Workers in oven's, soldiers, and travelers are often exposed to severe environmental heat stress, which may deteriorate their working efficiency and productivity and may even threaten their survival rate. It is thus expected that the physiological heat strain experienced by an individual will be related to the total heat stress to which he/she is exposed, serving the need to maintain body-core temperature within a relatively narrow range of temperatures. Many attempts have been made to estimate the stress inflicted by a wide range of work conditions and climate, or to estimate the corresponding physiological strain and to combine them into a single index (a heat stress index).

When the ambient temperature is outside of thermal comfort zones, the human body's thermal balance is lost. This is known as the heat stress. The heat stress, as a physical hazardous factor, is being raised in many workplaces (Leithhead and Lind , 1964 and Golbabaei and Omidvari ,2008)

Different studies show that the workers of mining, casting, bakeries, and smelting are strongly faced with the heat stress (Barth *et al*, 2002). In such situations, the human body makes some physiological responses, called as the strain, which cause the heart rate increment by 1 beat per minute for a one-degree increment in the body's temperature (Elieser,1973). The heart rate increment is a response to the central body's temperature which rises for rapid blood vessels, transferring the blood to the capillaries of skin surfaces, and cooling the blood (Plog *et al.*,1996).

Brotherhood (1987) states that the principal source of heat stress comes from the metabolic heat production arising from physical activities such as in sports. Other factors that contribute to heat stress are improper clothing and the thermal environment (air temperature, air movement, and radiant temperature). All these factors affect the heat exchange between the body and the environment which takes place at the skin surface (Brotherhood, 1987). Brotherhood further explains the role of heat stress in sports. Physical training and competition inherently produce extremely high metabolic heat loads. In hot conditions, sweat increases, as do deep body (core) temperature and skin temperature. Also, the heart rate and cardiac output increases.

In conclusion, Brotherhood's study of heat stress states that "an increase in environmental temperature may result in greater stress than the combined capacities of thermoregulation and heat dissipation can handle". This condition will cause a dangerous increase in the athlete's body temperature and skin temperature, affecting his/her performance, as well as his/her health and safety. High temperatures cause an increase in blood flow to the surface tissue, causing the heart to pump more blood to the muscles and to the skin resulting in a higher heart rate.

Skin temperature also plays a major role in the ability to tolerate heat (Brotherhood, 1987). In order to maintain optimal performance, the athlete's skin temperature, should be lower than 30 degrees Celsius

Acceptable Temperature Limits for Human Existence/Comfort

There is a range of temperature within which humans can live comfortably. Temperatures above and below this range brings various degrees of discomfort. For a given point, the temperature increases as the relative humidity (moisture content) of the air becomes higher. The following table gives ranges of temperature in degrees for various distances of people in the environment (Vereecken et. al., 2008 and Emoyam et. al.,2008) with higher temperature to the one with lower temperature.

Table 1: Acceptable Temperature limits for Human Comfort

Temperature (°C)	Degrees of Comfort
20 – 29	Comfortable
30 – 39	Varying degrees of discomfort
40 – 45	Uncomfortable
46 and Over	Many types of labour must be restricted

Source:-Canadian Centre for Occupational Health & Safety (1997-2014)

Http://www.Ccohs.Ca/Oshanswers/Phys_Agents/Hot_Cold.Htm

Beheshti *et. al.*, (2016) stated that heat stress is one of the harmful factors present in many workplaces. It can lead to performance loss and low functionality of the labour force. Therefore, the aim of their study was to evaluate exposure to heat stress as a consequence of temperature rise and its performance loss among workers functioning in indoor high-temperature workplaces. This descriptive, analytical study was conducted in high temperature ovens within Calabar environs.

In a related study, Epstein and Daniel (2006) noted that thermal stress is an important factor in many industrial situations, athletic events and military scenarios. It can seriously affect the productivity and the health of the individual and diminish tolerance to other environmental hazards. However, the assessment of the thermal stress and the translation of the stress in terms of physiological and psychological strain is complex. For over a century attempts have been made to construct an index, which will describe heat stress satisfactorily. The many indices that have been suggested can be categorized into one of three groups: “rational indices”, “empirical indices”, and “direct indices”.

Kjellstrom(2014), also designed a programme to carry out and facilitate research and analysis on effects of heat exposure on working people (including gender aspects and effects on pregnant women and on children), to quantify climate change-related increases in workplace heat exposures and the impact this will have on human health and productivity in different locations around the world. And to identify feasible ways to prevent or reduce such exposure and effects. Impacts of increasing heat on health equity and associated links to economic development and human rights will also be assessed. The ultimate aim was to improve the understanding of the potential working life consequences of climate change and to promote effective prevention.

Heat Stress and Heat Exchange

An essential requirement for continued normal body function is that the deep body temperature will be maintained within a very narrow limit of ± 1°C around the acceptable resting body core temperature of 37°C. To achieve this, body temperature equilibrium requires a constant exchange of heat between the body and the environment. The rate and amount of the heat exchanged is governed by the fundamental laws of thermodynamics. In general terms, the amount of heat that must be exchanged is a function of:(a). the total metabolic heat produced, which for a 70 kg young male, may range from about 80 watts at rest to about 500 watts for moderately hard industrial work (and up to 1,400 watts for a very trained endurance athlete) ;(b). the heat gained from the environment (≈17.5 watt per change of 1°C in ambient temperature, above or below 36°C). The amount of heat that can be exchanged is a function of sweat evaporation (≈18.6 watt per 1 mmHg change in ambient vapor pressure, below 42 mmHg (assuming a mean skin temperature of 36°C)). The basic heat balance equation is:

$$\Delta S = (M - W_{ex}) \pm (R + C) - E \tag{2.1}$$

Where: ΔS= change in body heat content;

$(M – W_{ex})$ =net metabolic heat production from total metabolic heat production

W_{ex}=mechanical work;

M=Mass of the body;

$(R + C)$=convective and radiative heat exchange;

E =evaporative heat loss.

In the situation of thermal balance ΔS=0, then:

$$(M – W_{ex}) \pm (R + C) = E_{req} \quad (2.2)$$

This form defines the required evaporation to achieve thermal balance (E_{req}). Noteworthy, evaporative capacity of the environment is in most of the cases lower than E_{req}; and thus, the maximal evaporative capacity of the environment (E_{max}) should be considered. The ratio $\frac{E_{req}}{E_{max}}$, which denotes the required skin wettedness to eliminate heat from the body, is a "Heat Strain Index" (HSI) that was proposed by Belding and Hatch7(Epstein and Moran, 2006).

The singular equations of $E_{req}$and E_{max} are beyond the scope of the present discussion; but, to solve these equations several parameters should be measured and eventually the interaction between them will define the human thermal environment (Epstein and Moran, 2006).

Description of the Study Area

Calabar, the capital of Cross River State is located in the southern part of Nigeria experiences a rare type of climate known as the tropical monsoon climate, Calabar is on Latitude 4°57'06"N and longitude 8°19'19"E at an elevation of 42m above sea level (Edet *et al*, 2017). The points marked blue on the map show the location of the bakeries that weres visited during the course of this investigation.

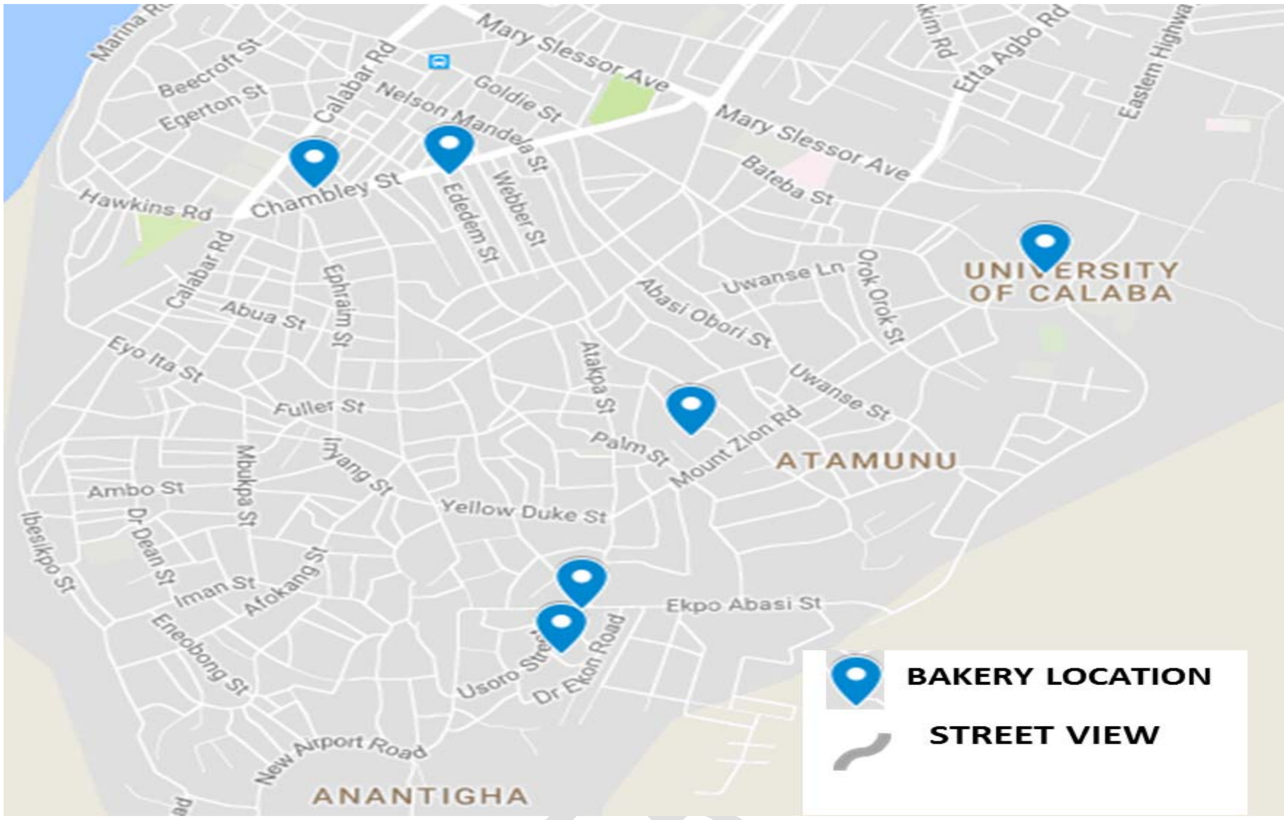

Figure 1; Map of the Study Location

Longitude and Lattitude

Location	Latitude	Longitude
Ekemini Bread (Effio-anwan Street) L1	$4^0$55’43.78”N	$8^0$19’38.14”E
Ekemini Bread(Atakpa Lane) L2	$4^0$56’22.56”N	$8^0$19’53.54”E
Ekemini Bread(Goldie by Mount Zion)L3	$4^0$56’51.44”N	$8^0$20’37.04”E
Spring Bread(Ededem Street) L4	$4^0$57’8.97”N	$8^0$19’24.72”E
Daybreak (Chamley Street) L5	$4^0$57’6.53”N	$8^0$19’8.16”E
Ekpo Abasi Street L6	$4^0$55’51.89”N	$8^0$19’40.83”E

MATERIALS AND METHOD

Materials

Thermometer :A thermometer is a device that measures temperature or a temperature gradient. A thermometer was used to record the readings of temperature

Meter Rule: A metre rule was used to measure the distance away from the source point (i.e. Oven), where the readings were taken.

Method

Temperature data were captured using a mercury in-glass thermometer. The data measurement were obtained at varied distances. The data were collected at six bakeries using fire wood oven in Calabar South environs.

Results

Interpretation of Results

Table 2; Showing Temperature of Bakery with varied distance from heat source (Oven), Ambient Temperature of the Bakery, Wind Speed inside the bakery at Ekemini Bakery

Distance	Temperature around oven	Ambient Temperature of the Bakery	ind Speed inside the bakery
Source Point	180	38	0.50
1	120	40	0.53
2	80	42	0.66
3	60	43	0.69
4	40	44	0.71
5	35	46	0.81

Table 3; Showing Temperature of Bakeryp with varied distance from heat source (Oven), Ambient Temperature of the Bakery, Wind Speed inside the bakery at Atakpa Lane(Ekemini Bread

Distance	Temperature around oven	Ambient Temperature of the Bakery	Wind Speed inside the bakery
Source Point	185	47.0	1.11
1	140	48.0	1.13
2	100	48.6	1.22
3	90	49.0	1.44
4	60	48.0	1.69
5	46	49.0	1.82

Table 4; Showing Temperature of Bakery with varied distance from heat source (Oven), Ambient Temperature of the Bakery, Wind Speed inside the bakery at Goldie by Mount zion (Ekemini Bread)

Distance	Temperature around oven	Ambient Temperature of the Bakery	Wind Speed inside the bakery
Source Point	185	44.4	2.14
1	140	44.5	1.86
2	80	43.9	1.91
3	60	43.3	1.47
4	45	42.1	1.75
5	43	41.4	1.49

Table 5; Showing Temperature of Bakery with varied distance from heat source (Oven), Ambient Temperature of the Bakery, Wind Speed inside the bakery sat Ededem(Spring Bread)

Distance	Temperature around oven	Ambient Temperature of the Bakery	Wind Speed inside the bakery
Source Point	161	40.2	0.83
1	120	40.5	0.95
2	100	41.3	1.10
3	80	41.7	1.16
4	60	42.4	1.29
5	40	43.0	1.36

Table 6; Showing Temperature of Bakery with varied distance from heat source (Oven), Ambient Temperature of the Bakery, Wind Speed inside the bakery at Daybreak Bakery (Chamley Street).

Distance	Temperature	Ambient Temperature	Wind Speed
Source Point	180	43.8	1.73
1	120	44.3	1.82
2	110	44.5	1.85
3	100	44.3	1.82
4	80	45.2	1.97
5	40	45.1	1.96

The temperature values varied with distances from heat source for all locations under study. At the source point (oven), the temperature obtain in location is extremely high but decrease with distance away from oven. Also a correlation plot of wind speed against ambient temperature was carried out.

Table 7; Showing Temperature of Bakery with varied distance from heat source (Oven), Ambient Temperature of the Bakery, Wind Speed inside the bakery.

Distance	Temperature	Ambient Temperature	Wind Speed
Source point	170	45.5	1.99
1	126	44.0	1.80
2	110	44.4	1.84
3	90	44.6	1.88
4	80	45.2	1.97
5	35	45.2	1.98

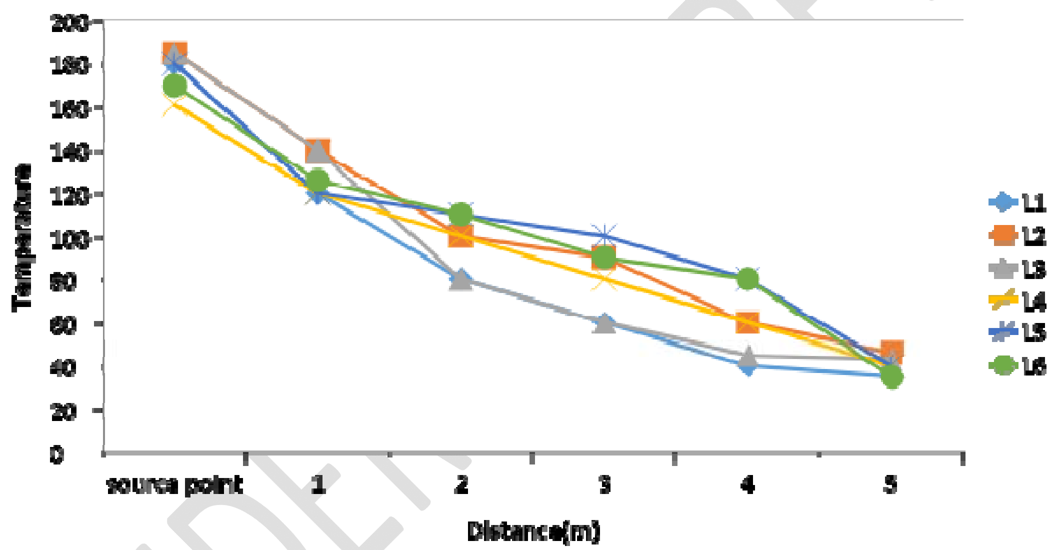

Figure 2; Temperature of oven variation with distance for all locations under study.

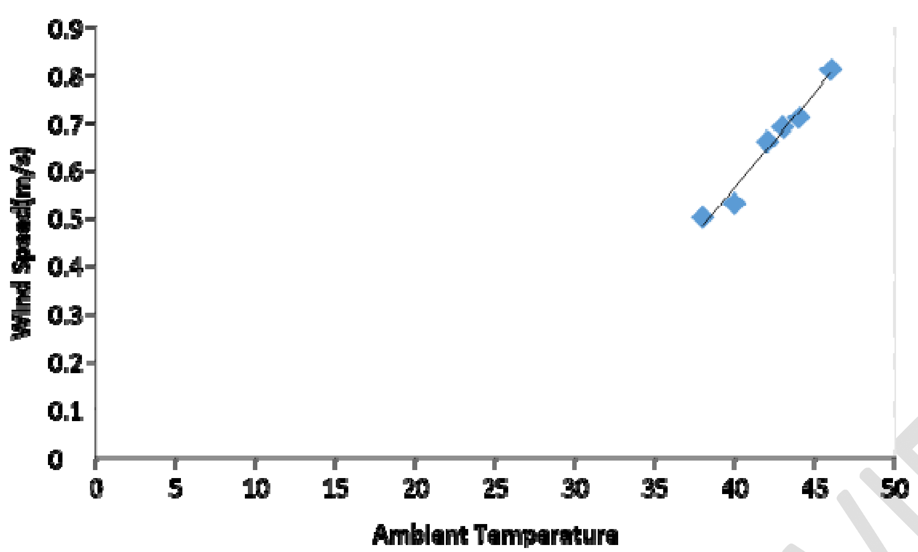

Figure 3; Correlation plot of Wind Speed against Ambient Temperature (Ekemini Bread)

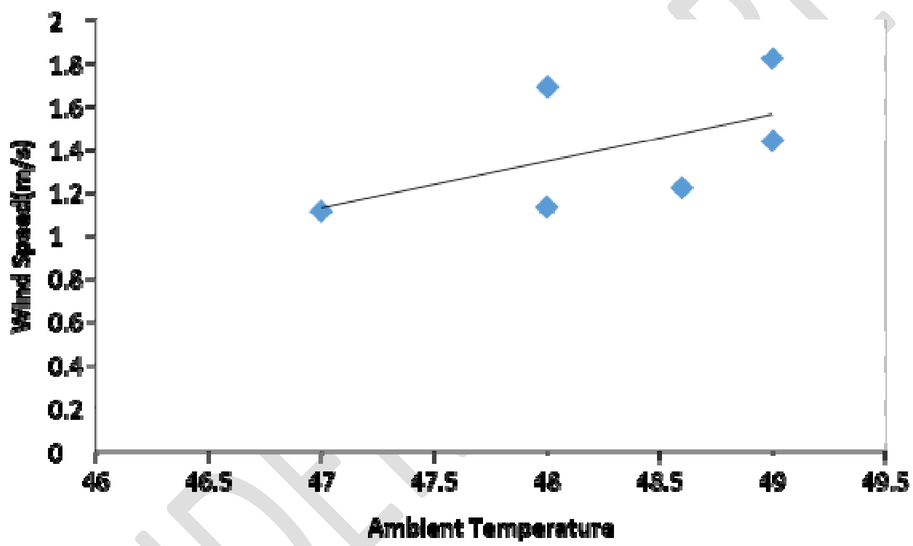

Figure 4; Correlation plot of Wind Speed against Ambient Temperature(Ekemini Bread at Atakpa lane)

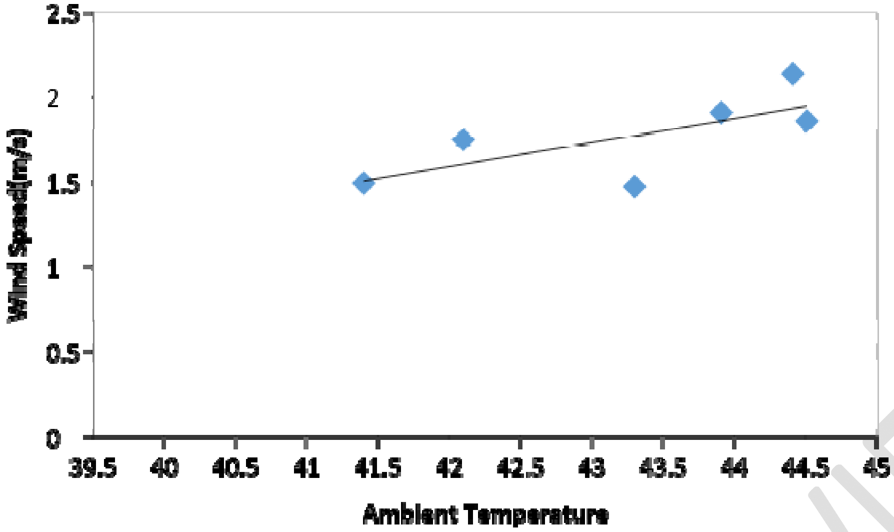

Figure 5; Correlation plot of Wind Speed against Ambient Temperature (Ekemini Bread)

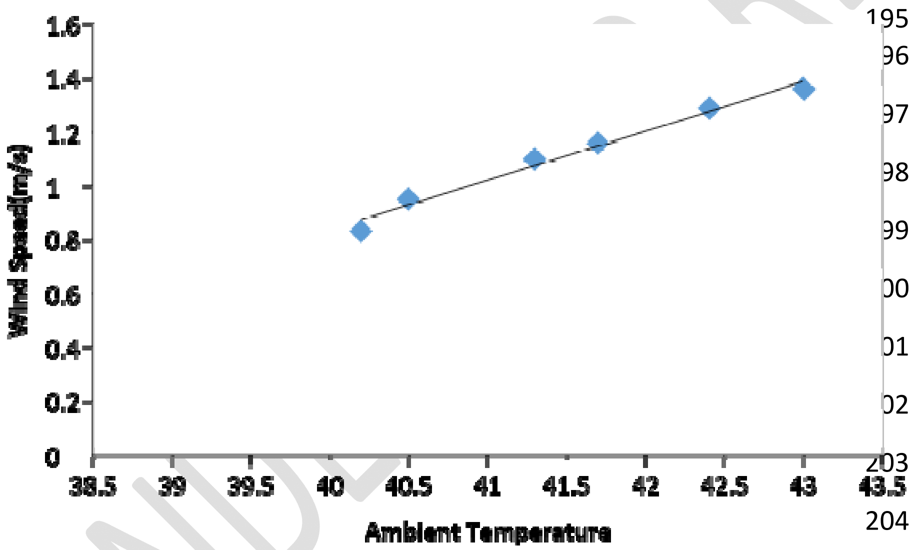

Figure 6; Correlation plot of Wind Speed against Ambient Temperature(Spring Bread at Ededem Street)

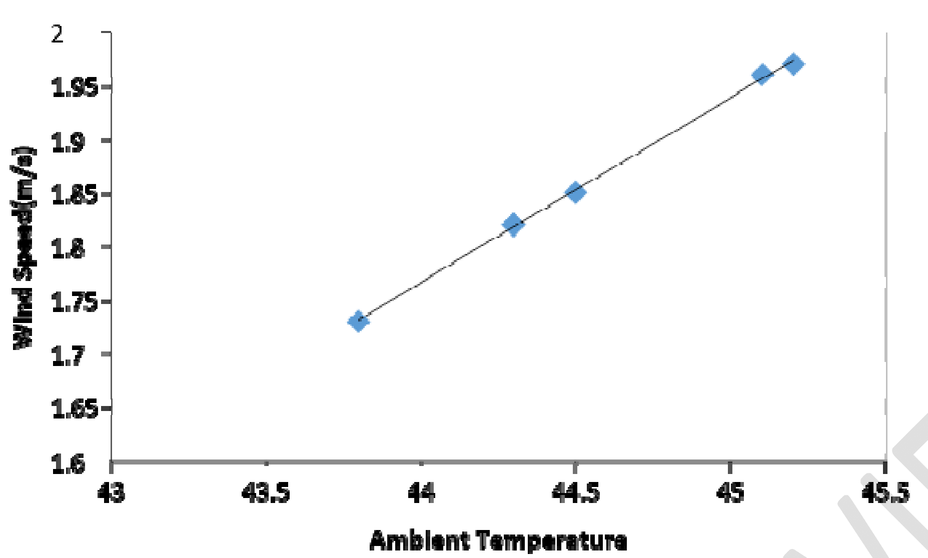

Figure 7; Correlation plot of Wind Speed against Ambient Temperature (Daybreak Bakery at Chamley Street)

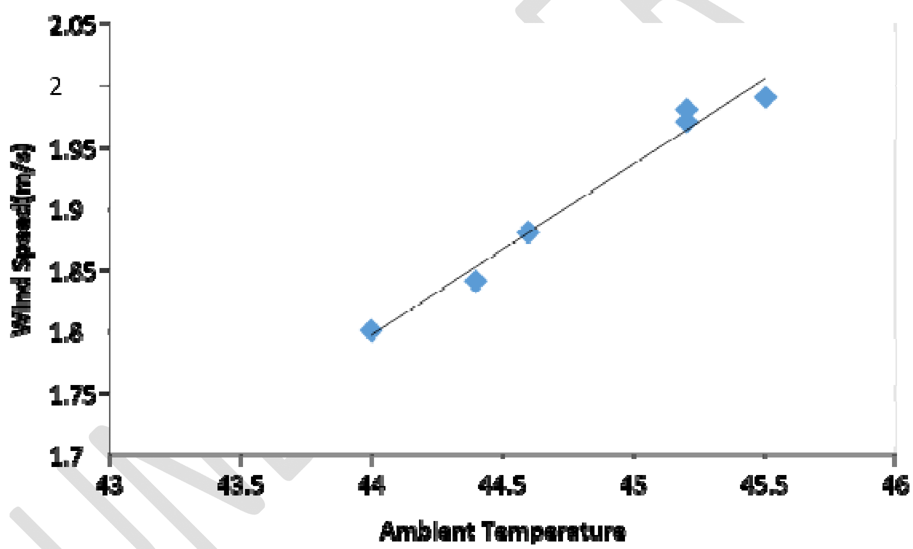

Figure 8 ; Correlation plot of Wind Speed against Ambient Temperature (Ekpo Abasi)

Discussion

Tables 1-6 show temperature values with varied distance from heat source for all locations under study. Figures; 2, shows a plot of temperature against distance while Figures;3-8 shows a Correlation plot of Wind Speed against Ambient Temperature which physically implies a positive correlation which here confirms a linear relationship between wind speed in Bakeries in Calabar South and temperature during the period under investigation. From the plots one thing is quite evident; at the source point (oven), the temperature values obtained in all locations at this point is extremely high but decreases with distance away from the oven as seen in Figures 2. Temperature values obtained in most locations if not all goes far beyond the acceptable temperature limits for human comfort recommended by World Health Organisation (WHO) as seen in Table 1(comfort temperature; 20-29^{0}C). The correlation coefficient obtained for wind speed and ambient temperature are; 0.98,0.55, 0.70,0.99,0.99 and 0.98 for all six locations respectively. The meaning is that as Temperature increases, wind speed also increases which is in agreement with (Kamgba *et al.,* 2017) and also confirms our results from the correlation plots. Based on R^2(coefficient of determination) value shown on each of the correlation plot (Figures;3-8), physically means that the models relating the Temperature and wind speed in each case respectively are good performing model which is in agreement with (Kamgba *et al.*, 2017). Therefore, the regression equation model is suitable for predicting wind speed for the study area (Calabar Bakery) under investigation based on the correlation coefficient and coefficient of determination.

Conclusion

Estimation background induced temperature emanating from Bakery Oven for Some Selected Locations in Calabar was investigated. It was found out that the temperature exposure of workers in all the bakeries under study exceeded the WHO exposure limit for comfort. All the bakeries visited during this study all used firewood industrial oven.

Base on the findings of this study, we recommend that; Electrical Ovens should be used instead of Firewood Oven because it is more work friendly for the avoidance of deforestation. Proper sensitization campaign should be done, teaching the workers how to maintain a healthy living by ensuring the usage of "FIRE PROOF" or any other gadget as some of them were naked during the period of this visit.

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