Asian Journal of Advanced Research and Reports

4(2): 1-10, 2019; Article no.AJARR.47998

Estimation of Background Induced Temperature in and Around Bakery Ovens for Some Selected Locations in Calabar

F. A. Kamgba[1*]

[1]Department of Physics, Cross River University of Technology, Calabar, Nigeria.

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJARR/2019/v4i230107
Editor(s):
(1) Dr. Shao-Yi Hsia, Associate Professor, Department of Mechanical & Automation Engineering, Kao-Yuan University, Kaohsiung City 82151, Taiwan, R.O.C.
Reviewers:
(1) Venkata Sanyasi Seshendra Kumar Karri, GITAM University, India.
(2) Jing-Min Wang, St. John's University, Taiwan.
(3) Bharat Raj Singh, Dr. APJ Abdul Kalam Technical University, India.
Complete Peer review History: http://www.sdiarticle3.com/review-history/47998

Original Research Article

Received 30 January 2019
Accepted 16 April 2019
Published 24 April 2019

ABSTRACT

Estimation of background induced temperature from six selected Bakery Ovens in Calabar was investigated. An in-situ measurement approach was adopted in order to quasi-accurately estimate temperature of Oven; wind speed in bakery and ambient temperature around the 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°C -29°C) exposure limit for comfort. All the bakeries visited during this study used firewood industrial oven.

Keywords: Heat; oven; bakery; wind speed; temperature estimation.

**Corresponding author: Email: fakamgba@crutech.edu.ng;*

1. INTRODUCTION

Beheshti et al. [1] recognized heat as a harmful physical factor in many workplaces. He observed that thermal stress due to heat was caused by a number of internal and external thermal factors which could lead to fatigue and development of disease conditions in the human body. Accordingly, his assertion showed that environmental heat influences the performance and productivity of humans through changes in physiological parameters, such as blood flow and hormonal release rate.

Heat exposure is a threat to performance, as well as to the health of *humans* who are working in heat related environment. Workers in ovens, 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).

It was opined that 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 [2] and [3].

Different studies showed that workers of mining, casting, bakeries, and smelting are strongly faced with the heat stress [4]. In such situations, the human body makes some physiological responses, known as strain, which increases the heart beat rate per minute for a one-degree rise in the body's temperature [5]. 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 [6].

Brotherhood [7] stated that the principal source of heat stress comes from the metabolic heat production arising from physical activities such as in sports. Other factors that also 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 [7]. 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 stated 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 [7]. In order to maintain optimal performance, the athlete's skin temperature, should be lower than 30 degrees Celsius.

1.1 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 [8] and [9] with higher temperature to the one with lower temperature.

Table 1. Acceptable temperature limits for human comfort [10]

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

Beheshti et al. [1] also opined that the presence of heat stress in many workplaces can lead to performance loss and low functionality of the labour force. Therefore, the objective of this 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 and establishes background related temperature values as a benchmark for future studies. This descriptive, analytical study was conducted in high temperature ovens within Calabar environs.

In a related study, [11] 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 et al. [12], also designed a programmed to carry out and facilitate research and analysis on the effects of heat exposure on working environment by workers, to quantify climate change-related increases in work place 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 was assessed. The ultimate aim was to improve the understanding of the potential working life consequences of climate change and to promote effective prevention [13] and [14].

1.2 Heat Stress and Heat Exchange

According to Eptein and Daniel [11], an essential requirement for continued normal body function is that the deep body temperature will be maintained within a very narrow limit of ± 1℃ around the acceptable resting body core temperature of 37℃. They opined that to achieve an equilibrium body temperature, it requires a constant exchange of heat between the body and the environment. This rate and amount of the heat exchanged is governed by the fundamental laws of thermodynamics. However, the amount of heat that must be exchanged is a function of 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); the heat gained from the environment (≈17.5 watt per change of 1℃ in ambient temperature, above or below 36℃). 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℃)). The basic heat balance equation is:

$$\Delta S = (M - W_{ex}) \pm (R + C) - E \qquad (1)$$

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 ∆S=0, then:

$$(M - W_{ex}) \pm (R + C) = E_{req} \qquad [11] \qquad (2)$$

This equation 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 [15].

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 [11].

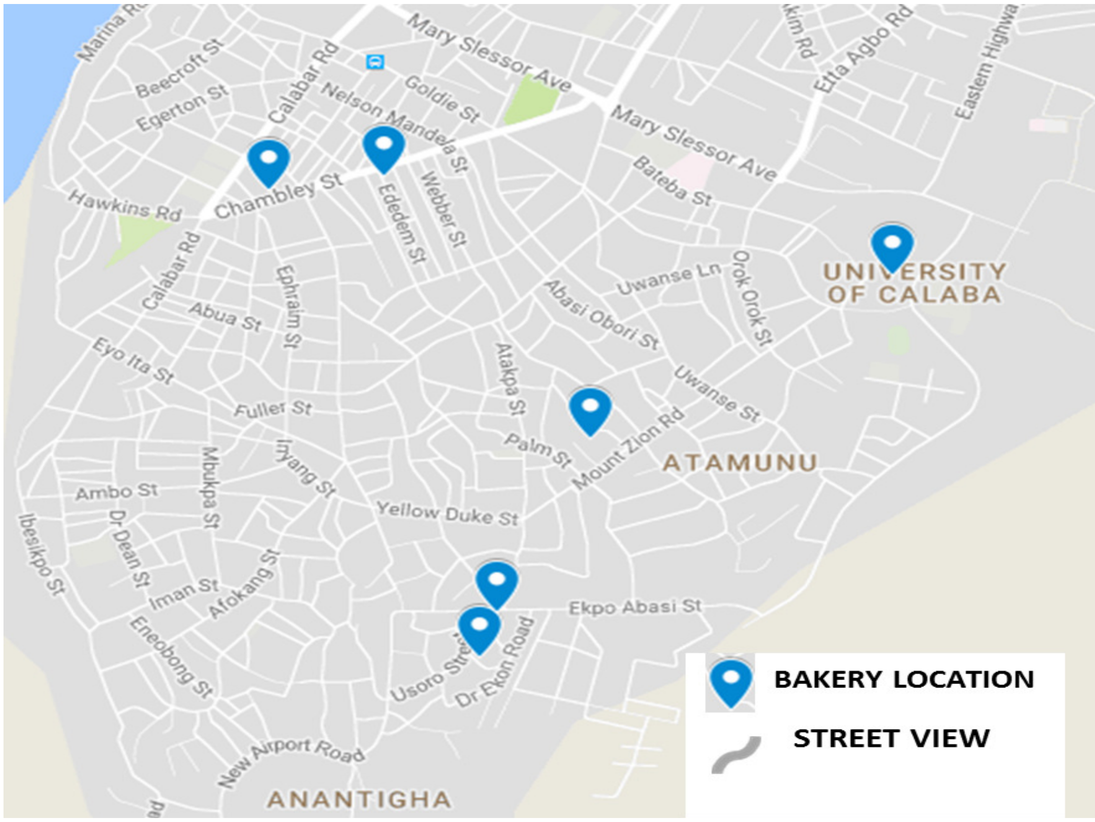

Fig. 1. Map of the study location

1.3 Description of the Study Area

Calabar, which is the capital of Cross River State, is located in the southern part of Nigeria. Its 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. The points marked blue on the map show the location of the bakeries that were visited during the course of this investigation [16].

2. MATERIALS AND METHODOLOGY

2.1 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.

2.2 Methods

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.

3. RESULTS

3.1 Interpretation of Results

The results of temperature measurements in degree centigrade from Tables 2-6 show that there is a corresponding decrease in temperature values in degree centigrade from the source points with varied distances in meters away from for all locations under study. At all the source points (oven), the temperature obtained ranges between 170 °C - 175 °C. This suggests that the heat distribution occasioned by this hike in temperature is also high but decreases with increase distances away from oven. A correlation plot of wind speed against ambient temperature was carried out in Figs. 3 - 8.

Table 2. Showing locations of bakeries in survey area, Calabar

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
EkpoAbasi Street L6	$4^0$55'51.89"N	$8^0$19'40.83"E

Table 3. Showing temperature of bakery with varied distances from heat source (oven), ambient temperature of the bakery, wind speed inside the bakery at Ekemini Bakery

Distance	Temperature around oven (°C)	Ambient Temperature of the Bakery (°C)	Wind Speed inside the bakery (ms^{-1})
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 4. Showing temperature of bakery with varied distances from heat source (oven), ambient temperature of the bakery, wind speed inside the bakery at Atakpa Lane (Ekemini Bread)

Distance	Temperature around oven (°C)	Ambient Temperature of the Bakery (°C)	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 5. 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 (m)	Temperature around oven (°C)	Ambient Temperature of the Bakery (°C)	Wind Speed inside the bakery (ms^{-1})
Source Point	185	44.4	1.49
1	140	44.5	1.47
2	80	43.9	1.75
3	60	43.3	1.86
4	45	42.1	1.91
5	43	41.4	2.14

Table 6. Showing temperature of bakery with varied distance from heat source (oven), ambient temperature of the bakery, wind speed inside the bakery at Ededem (Spring Bread)

Distance (m)	Temperature around oven (°C)	Ambient Temperature of the Bakery (°C)	Wind Speed inside the bakery (ms^{-1})
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 7. Showing temperature of bakery with varied distances from heat source (oven), ambient temperature of the bakery, wind speed inside the bakery at Daybreak Bakery s (Chamley Street)

Distance (m)	Temperature (°C)	Ambient Temperature (°C)	Wind Speed (ms^{-1})
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

Table 8. Showing temperature of bakery with varied distances from heat source (oven), ambient temperature of the bakery, wind speed inside the bakery

Distance (m)	Temperature (°C)	Ambient Temperature (°C)	Wind Speed (ms^{-1})
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

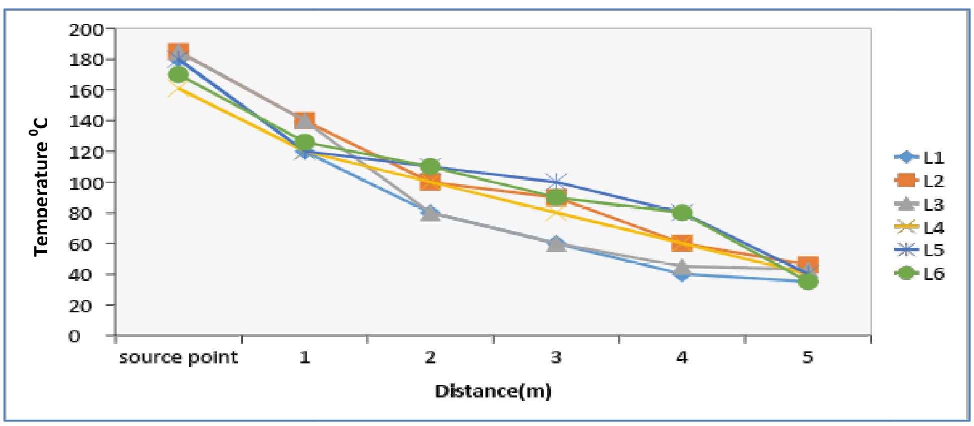

Fig. 2. Temperature of oven variation with distance for all locations under study

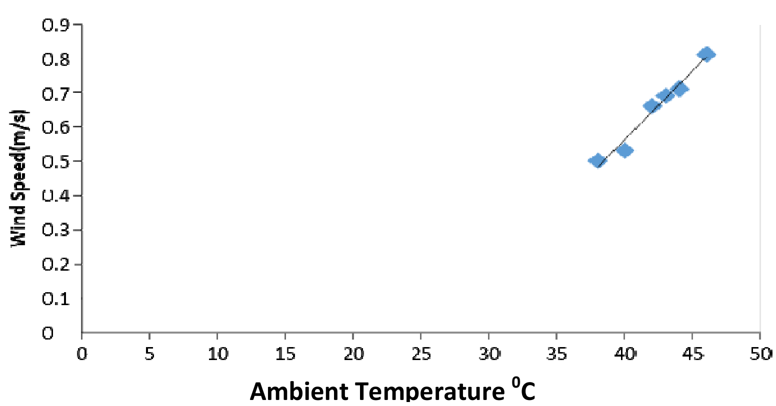

Fig. 3. Correlation plot of wind speed against ambient temperature (Ekemini Bread)

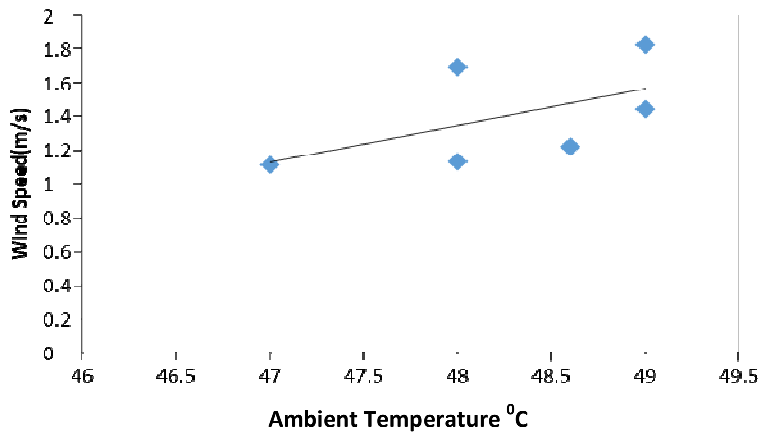

Fig. 4. Correlation plot of wind speed against ambient temperature (Ekemini Bread at Atakpa lane)

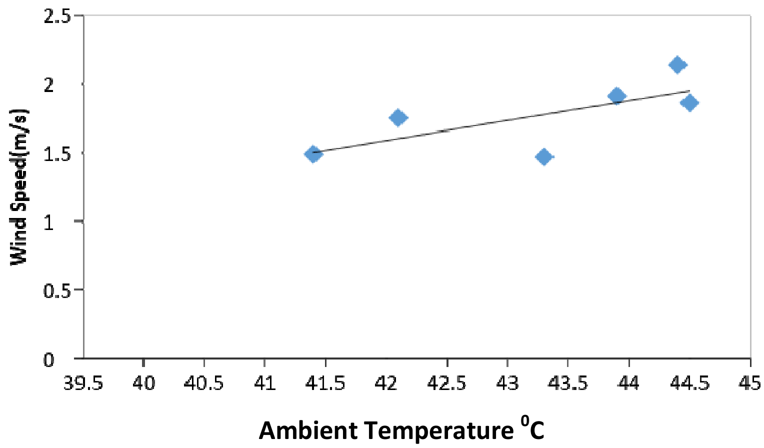

Fig. 5. Correlation plot of wind speed against ambient temperature (Ekemini Bread)

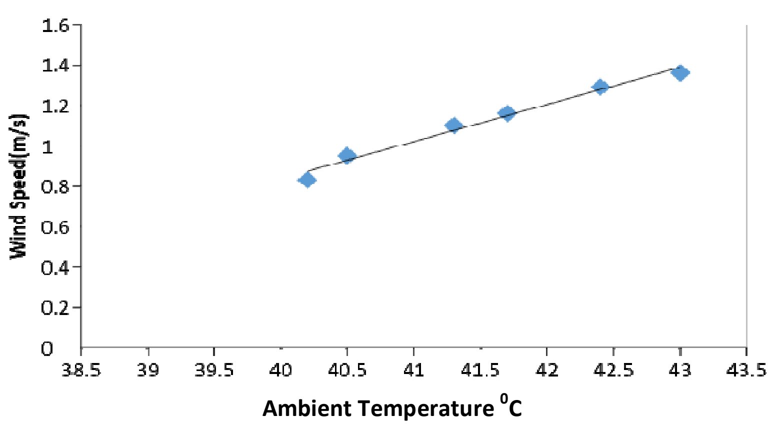

Fig. 6. Correlation plot of wind speed against ambient temperature (Spring Bread at Ededem Street)

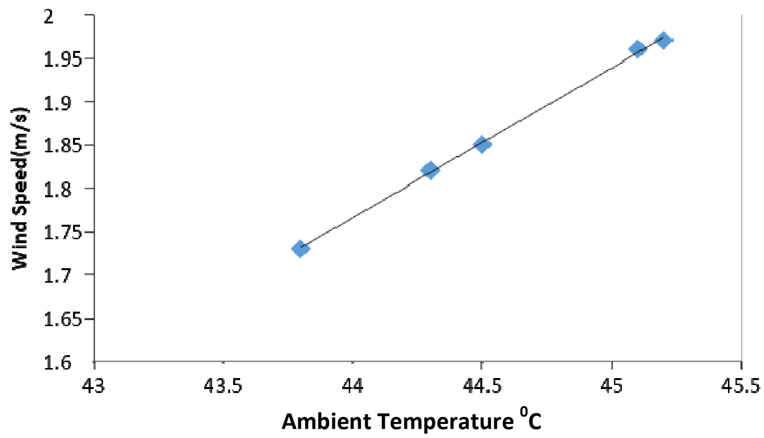

Fig. 7. Correlation plot of wind speed against ambient temperature (Daybreak Bakery at Chamley Street)

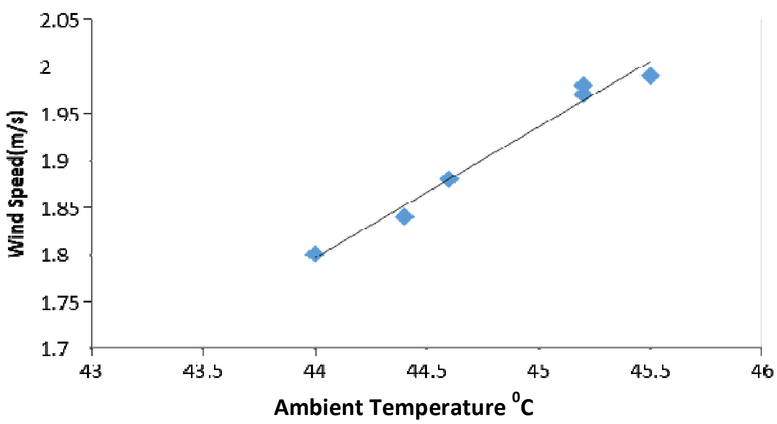

Fig. 8. Correlation plot of wind speed against ambient temperature (Ekpo Abasi)

4. DISCUSSION

Tables 1-6 show temperature values in °C with varied distance in metres from heat source for all locations under study. Fig. 2, shows a plot of temperature against distance while Figs. 3-8 shows a Correlation plot of Wind Speed in metre per second against ambient temperature in °C. These graphs physically define a positive correlation which 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 are extremely high but decreases with distance away from the oven as seen in Fig. 2. Temperature values obtained in most locations if not all goes far beyond the acceptable temperature limits for human comfort recommended by World Health Organization (WHO) as seen in Table 1 (comfort temperature; 20-29℃). The correlation coefficient obtained for wind speed and ambient temperature using microsoft excel software is presented as follows; 0.98,0.55, 0.70,0.99,0.99 and 0.98 for all six locations respectively. The meaning is that as the ambient temperature increases, the wind speed in the bakeries also increases which is in agreement with [17] and also confirms our results from the correlation plots. The values of correlation infer that 98%; 55%; 70%, 99% and 98% positive relationship between wind speed increase and temperature rise as we traverse the entire graphs. Based on R^2(coefficient of determination) value shown on each of the correlation plot (Figs. 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.

5. CONCLUSION

In a survey conducted to estimate the level of background induced temperature emanating from Six Selected Bakery Ovens in Calabar using in-situ measurement approach, it was noted that;

i. As the ambient temperature increases, the wind speed in the bakeries also increases,
ii. There is also a positive correlational relationship between wind speed and temperature values as both increases with the increase in one.
iii. The exposure of workers in all the bakeries under study exceeded the WHO exposure limit for comfort.
iv. All the bakeries visited during this study used firewood industrial oven.
v. Based on the findings of this study, we recommend that; Electrical Ovens should be used instead of Firewood Ovens 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.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Beheshti MH, Boroumand Nejad E, Bahalgerdy B, Mehrafshan F, and Zamani Arimy A. Performance loss among workers due to heat stress in High-Temperature work places. JOHE Spring. 2015;4(2).
2. Golbabaei F, Omidvari M. Man and thermal environment 2nd Ed. Tehran; University of Tehran Publication; 2008.
3. Leithhead CS, Lind AR. (1964). Heat Stress and Heat Disorders. Cassell & CO Ltd, London, UK. Golbabaei F, Omidvari M. Man and thermal environment. 2nd ed. Tehran: University of Tehran Publication; 2008.
4. Barth RC, George PD, Hill RH. Environmental health and safety for hazardous waste sites. London: AIHA; 2002.
5. Elieser K. Relationship of physiological strain to change in heart rate during work in heat. American Industrial Hygiene Association Journal. 1972;33(11):701-708.
6. Plog BA, Niland J, Quinlan PJ. Fundamentals of industrial hygiene. Chicago: National Safety Council; 1996.
7. Brotherhood JR. The practical assessment of heat stress. In J. R. S. Hales & D. A. B. Richards (Eds.), Heat Stress: Physical Exertion and Environment. New York: Elsevier Science Publishing. 1987;451-468.
8. Vereecken H, Huisman JA, Bogena H, Vanderborght J, Vrugt JA, Hopmans JW. On the value of soil moisture measurements in vadose zone hydrology: A review; Water Resources Research. 2008;44:W00D06. DOI:10.1029/2008WR006829, Available:https://jasper.eng.uci.edu/pdf/40.pdf
9. Emoyan OO, Akpoborie IA, Akporhonor EE. The oil and gas industry and the Niger Delta: Implications for the environment. Journal of Applied Sciences and Environmental Management. 2008;12(3): 29-37.
10. ANSI/ASHRAE Standard 55-2013 Thermal Environmental Conditions for Human Occupancy.
11. Eptein Y, Daniel SM. Thermal comfort and heat stress indicies. Industrial Health. Industrial Health. 2006;44(3):388-398.
12. Kjellstrom T, Holmer I, Lemke B. Workplace heat stress, health and productivity – an increasing change for low and middle-income countries during climate change. Global Health Action. COACTION PUBISHING; 2009.
13. Desjarlais, Andre O. which kind of Insulation is Best? Oak Ridge National Laboratory, retrieved 5 May 2013 "U Value Measurement Case Study". (Retrieved 2014-October-29)
14. McGee H. On food and cooking. The Science and Lore of the Kitchen, New York: Schuster; 1984.

15. Ro-Ting Lin, Chang-Chuan Chan. Effects of Heat on workers' Health and Productivity in Taiwan, Global Health Action. Global Health Action. COACTION PUBLISHING; 2009.
16. Edet CO, Eno EE, Ettah EB, Kamgba FA. Seasonal variation of radio refractivity in Calabar Nigeria. International Journal of Scientific Research Engineering & Technology. 2007;6(6):670-673.
17. Kamgba FA, Edet CO, Njok AO. Effects of some meteorological parameters on wind energy potential in Calabar, Nigeria. Asian Journal of Physical and Chemical Sciences. 2017;4(1):1-7.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/47998