Assessment of Carbon Monoxide Emission Levels on the Floors of some Selected Bakeries in Southwestern Nigeria

Olayemi Odunlami, Chinoso Emekekwue, Fransis Elehinafe, Muyiwa Fajobi and Olubunmi Abioye

***Abstract* - The carbon monoxide (CO) emission levels were assessed using ALTAIR XCELL 5X Multi-gas monitor in four bakeries in Ota, Ogun State, Southwestern Nigeria. The results showed that ovens are potential sources of the emission of carbon monoxide which readily combines with hemoglobin in the blood, thereby contributing to the indoor air contaminants in bakeries. The data obtained was analyzed and the CO emission levels were higher than the indoor standard of 9 ppm recommended for 8 hours by USEPA (United States Environmental Protection Agency) when the ovens were being heated at the bakeries due to incomplete combustion fuels used. The CO mean concentrations were 12.33 pm for bakery 1, 136.93 ppm for bakery 2, 135.46 ppm for bakery 3 and bakery 4 didn't have detectable limits of CO by the monitor deployed. For the safety of workers and consumers in bakeries, regular inspection should become a priority for the various environmental regulatory agencies involved.**

***Index Terms*: Air emissions, carbon monoxide, bakeries, exposure**

I. INTRODUCTION

Wood burning ovens are generally cheap when compared to non-renewable energy sources. Wood is a polymer of celluloses, polyoses and lignin with extents of different minerals and concentrates relying upon the wood species [3]. The heat energy from firewood is around 17–19 MJ/kg [3]. Subject to how the oven is run, set up and sustained, as well the firewood itself, a widespread array of other combustion products are let off in addition to carbon dioxide and carbon monoxide [6,7]. These principally consist of the normal combustion products cellulose, aldehyde and particulate matter [5]. It has been known that fire sources in rooms can increase the level of indoor air contamination.

The use of solid fuel in homes and bakeries is, particularly in developing countries, an important source of indoor air pollution. Globally (including indoor cooking emissions), household air pollution accounted for about 4.3 million premature deaths in 2012 [10,11]; Whereas the use of coal for residential purposes is decreasing in general over Europe, there is currently a growing interest in the use of wood/biomass in residential energy production, as a source of renewable energy [2]. It is well-known that wood (and biomass, in general) is a renewable source of energy, with evident advantages with regard to climate. When combusted efficiently, it may be a (nearly) CO_2-neutral source of energy, even if it does generate emissions of other atmospheric pollutants. However, the use of wood as residential fuel under non-optimal operating conditions (e.g., with non-regulated stoves, non-commercial fuels such as recycled wood, stoves lacking proper maintenance or bad burn practices) entails negative consequences.

This report focuses on the levels of exposure to CO emission on the floors of bakeries from ovens which are the sources of the emission of carbon monoxide. Series of sampling were carried out in various sampling points on the floor of the four bakeries selected. The concentrations of carbon monoxide emission measured from the bakeries were compared with the indoor hygiene criteria by USEPA (United States Environmental Protection Agency).

O. Odunlami is with the Department of Chemical Engineering, Covenant University, Ota, Ogun State, Nigeria, e-mail: olayemi.odunlami@covenantuniversity.edu.ng
C. Emekekwue, F. Elehinafe, M. Fajobi and O. Abioye are lecturers in Covenant University, Ota, Ogun State, Nigeria.

II MATERIALS AND METHODS

A. The Study Area

The study area is Ota, Ogun State (Figure 1). It is found in the southwestern region of Nigeria. It covers an approximate area of 1.46km^2 (square kilometers) and runs an approximate distance of 5.08km [4]. Ota is a town in Ogun State, Nigeria, and has an estimated 163,783 residents living in or around it. Ota is the capital of the Ado-Odo/Ota Local Government Area.

Figure.1: A map of the study area **[4]**

ISBN: 978-988-14049-2-3
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

B Procedure

The ALTAIR XCELL 5X Multi-gas sensor was used to measure the CO emission concentrations from the selected four bakeries in Ota. Four sampling points in each of the bakeries were identified based on the floors of the working sections of the bakeries. The identified sampling points are denoted by A, B, C and D while the bakeries are named 1, 2, 3 and 4. Bakeries 1, 2, and 3 are fired using firewood while bakery 4 is fired using Automotive Gas Oil (AGO). The carbon monoxide emission measurements were taken for one hour at 2 min intervals when the ovens were being heated and during baking. The gas monitor was switched on and allowed to initialize, for all internal systems to be ready. The gas monitor was placed in the range of 1.5 to 2.0 m above the floors to target the air being inhaled.

III RESULTS AND DISCUSSION

The results of this study are presented and discussed here i.e. the identified sampling points, the mean concentrations of carbon monoxide at the identified sampling points of the various bakeries for two activities which included the heating period of the oven and baking period.

A. The Identified Sampling Points Within the Four Selected Bakeries

The sampling points are: Point A where the burners were situated. Workers occasionally go there to sustain the fire and heat that is being generated. Combustion takes place at this point. It is the source of the emission; Point B, the mixing zone, where the pastry dough was prepared and mixed. It is situated not too far from the oven. Doughs were mixed by the workers at this point; Point C, the packing area, where finished products (bread) were allowed to cool, packaged and sealed by workers; and Point D, the finished products are stored.

The bakeries are; Bakery 1: Standard bakery with its stacks positioned high enough towards the roof, out of the building. It has one wood fired oven; Bakery 2: A converted building, built as a house, it has one wood fired oven; Bakery 3: A house that was converted to a bakery, without adequate bakery structure and has just one oven which is also wood fired; and Bakery 4: Standard bakery which was built solely as a bakery with 3 ovens fired with diesel.

B. The Mean Concentrations of Carbon Monoxide Emissions in the Identified Sampling Points from the Selected Bakeries

Tables 1 shows the mean concentrations of CO emission level at all the sampling points in all the bakeries during the heating period.

Table 1: Mean concentrations of CO levels at the identified sampling points in the selected bakeries (this study)

Sampling Point	Bakery 1 CO (ppm)	Bakery 2 CO (ppm)	Bakery 3 CO (ppm)	Bakery 4 CO (ppm)
A	121.33	136.93	135.46	0.00
B	0.40	13.10	12.60	0.00
C	0.60	24.73	21.30	0.00
D	0.20	6.26	0.10	0.00

B. Discussion of Results

Nowadays, bakeries are built with ovens installed in them. The associated exposure to indoor emissions by workers cannot be over emphasized depending on the type of fuels used and the design of the bakeries putting into consideration the fired-chambers of the installed ovens. The results of the study conducted on four selected bakeries are discussed here. Table 1 shows the mean concentration of CO emission at the four selected sampling points in all the four identified bakeries during the heating period. At sampling point A, concentrations of CO emission were higher than the USEPA indoor exposure CO standards at bakeries 1, 2, and 3 due to incomplete combustion of firewood used as fuel. The concentrations ranged between 121.33 ppm for bakery 1 and 136.93 ppm for bakery 2. CO emission was not detected at sampling point A in bakery 4 due to complete combustion of AGO used as fuel. So, exposure to CO emission is certain around the wood-fired burners of ovens in bakeries whether standard bakeries or converted-building bakeries.

At sampling point B, concentrations of CO emission were higher than the statutory of CO indoor exposure standards of USEPA for indoor environment in bakeries 2 (13.10 ppm) and 3 (12.60ppm). In bakery 1, it was 0.40 ppm which was below the statutory standard while it was not detected in bakery 4. The mixing zone in bakery 1 was having CO emission concentration far below the standard because the bakery is standard and its stack was well designed and positioned to prevent indoor pollution. Bakeries 2 and 3 had their mixing zone polluted for they are converted-building bakeries having their stacks poorly designed and erected. Bakery 4 is a standard bakery with is stack well designed and its oven is AGO fired giving the complete combustion of the fuel.

ISBN: 978-988-14049-2-3
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

At the sampling point C, concentrations of CO emission were higher than the statutory of CO indoor exposure standards of USEPA with the concentrations 24.73 ppm in bakery 2 and 21.60 ppm in bakery 3. In bakery 1, it was 0.60 ppm which was below the statutory standard while it was not detected in bakery 4. At the sampling point C, bakery 1 had CO emission reasonably below the indoor standard of USEPA because the bakery is standard and its stack was well positioned and constructed to avoid indoor pollution. Bakeries 2 and 3 had their sampling point C polluted because they were converted-building bakeries having their stacks badly designed and erected.

At sampling point D, the section where the finished products are brought here by the workers to be stored, concentrations of CO emission were lower than the statutory of CO indoor exposure standards of USEPA with the concentrations 0.20 ppm in bakery 1, 6.26 ppm in bakery 2, and 0.10 ppm in bakery 3, CO emission was not detected in bakery 4. Distances played a role here. Generally, in each of the bakeries, the sampling point D is situated for away from the ovens almost outside the bakeries.

IV. CONCLUSION

It was concluded at the end of this study that: Ovens emit considerable amount of carbon monoxide during operations within wood-fired bakeries which affect the indoor air quality. Standard or converted-building bakeries determine whether or not there would be exposure to CO emission on the floor of the bakeries. The construction of stacks, the type of fuel used for firing the ovens and the distance from the oven used play important roles in the levels of emission of CO on the floors of bakeries.

ACKNOWLEDGEMENT

The authors wish to acknowledge the financial support offered by Covenant University in actualization of this research work for publication.

REFERENCES

[1] M. Cerqueira, L. Gomes, L. Tarelho and C. Pio Formaldehyde and acetaldehyde emissions from residential wood combustion in Portugal. *Atmospheric environment*, *72*, 2013, pp 171-176.
[2] EC, 2009. On the promotion of the use of energy from renewable sources, EC DIrective 2009/28/EC.
[3] D. Fengel and G. Wegener (Eds.) *Wood: chemistry, ultrastructure, reactins*. Walter de Gruyter 2011.
[4] Google Maps, 2019.
[5] E. Hedberg, A. Kristensson, M. Ohlsson, C. Johansson, P. Johansson, E. Swietlicki, ... and R. Westerholm. Chemical and physical characterization of emissions from birch wood combustion in a wood stove. *Atmospheric Environment*, *36*(30), 2002, pp 4823-4837.
[6] J. McDonald, B. Zielinska, E. Fujita, J. Sagebiel, J. Chow and J. Watson. Fine particle and gaseous emission rates from residential wood combustion. *Environmental Science & Technology*, *34*(11), 2000, pp 2080-2091.
[7] O. Odunlami, F. Elehinafe, T. Oladimeji, M. Fajobi, F. Akeredolu, O. Okedere, and Fakinle, B. S. Implications of lack of maintenance of vehicles on ambient air quality. *International Journal of Mechanical Engineering and Technology (IJMET)*, *9*(9) , 2018, pp 647-654.
[8] O. Odunlami, F. Elehinafe, A. Pearl, O. Abatan, O, and A. Mamudu, Assessment of carbon monoxide emission from different brands of split air-conditioners. *International Journal of Mechanical Engineering and Technology (IJMET)*, *9*(9), 2018, pp 655-662.
[9] T. Ward, C. Palmer, M. Bergauff,, K. Hooper, and C. Noonan, Results of a residential indoor PM2. 5 sampling program before and after a woodstove changeout. *Indoor air*, *18*(5), 2008, pp 408-415.
[10] WHO, Household fuel combustion WHO Guidelines for Indoor Air Quality 2014.
[11] WHO, Residential heating with wood and coal: health impacts and policy options in Europe and North America. Copenhagen, Denmark 2015.

ISBN: 978-988-14049-2-3
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)