

Indoor Air Quality in Commercial Kitchens

E. Shirin Hima Bindu¹, Mahalakshmi V. Reddy²

¹Ph.D. Research Scholar, Department of Resource Management and Consumer Sciences, College of Home Science, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana

²Professor & Head, Department of Resource Management and Consumer Sciences, College of Home Science, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana

Abstract: *Indoor air quality has become an important occupational health and safety concern in several workplaces including commercial kitchens. This study investigated the carbon dioxide, carbon monoxide and particulate matter emissions in indoor air of three different types of commercial kitchens viz., Restaurants, Catering centre and Fast-food centre. The selected parameters were monitored using an air quality monitor during the cooking activities in the commercial kitchens. In the study it was observed that all the three cooking environments had CO₂ levels above 1000 ppm. For Carbon monoxide it was observed that restaurants, catering centres and fast food centres indicated 7ppm, 8.8ppm and 9.4ppm respectively which are above the permissible exposure levels. The mean concentration of PM₁₀ in restaurants, catering centres and fast food centres was 2.68 mg/m³, 3.84 mg/m³ and 3.58 mg/m³ respectively. In catering centres PM₁₀ levels are found to be the highest. The mean concentration of PM₄ in restaurants, catering centres and fast food centres was 2.54 mg/m³, 3.64 mg/m³ and 3.06 mg/m³ respectively. In restaurants and fast food centres it is within the acceptable limits and in catering centres it is found to be high. The mean concentration of PM_{2.5} in restaurants, catering centres and fast food centres was 2.56 mg/m³, 3.28 mg/m³ and 3.56 mg/m³ respectively. PM_{2.5} is found to be highest in the fast food centres. In conclusion awareness regarding improved cooking practices is still poor. Ergonomically designed interior layout and good exhaust systems reduces indoor particulate matter concentration. It is recommended that there should be increased awareness among the workers.*

Keywords: Indoor air quality, Particulate matter, Commercial Cooks, Commercial kitchens, Emissions

1. Introduction

'Cooking fumes' or 'cooking oil fumes' is the term commonly used to describe the visible emissions generated during cooking by frying with oil. In occupational and environmental hygiene, 'fumes' are defined as submicron-sized solid particles (particulate matter) created by the cooling of hot vapour. During cooking, such vapour is formed when the cooking oil is heated above its boiling point. In addition to this ultrafine particulate matter, cooking, especially frying and grilling, generates aerosol oil droplets, combustion products, organic gaseous pollutants, and steam from the water contents of the food being cooked [1].

Cooking, in particular frying, generates substantial amounts of airborne particulate matter (PM), which includes ultrafine particles (UFP) and fine PM (PM_{2.5}), and is a major contributor to their indoor levels. In addition, particles created during cooking have organic substances adsorbed on their surface [2]. These include polycyclic aromatic hydrocarbons (PAHs) and heterocyclic amines. Certain gaseous pollutants such as Carbon dioxide, Carbon monoxide [3], particulate matter [4] are also produced during cooking. Cooks are prone to heat stress and exposed to poor indoor air quality at work place due to heat and particulate matter generated from cooking practices especially in tropical countries like India.

The aim of this study was to carry out air quality surveys in 15 commercial kitchens and provide continuous monitoring of pollutants. The continuous monitoring of the pollutants not only provided an assessment of any peak levels but also an indication of personal exposure to low level background pollutant levels which has adverse health effects.

2. Materials and Methods

Exploratory research design was selected for conducting this study. To assess the indoor air quality, a sample of 15 different commercial kitchens viz., Restaurants, Catering centre and Fast-food centre situated in and around Hyderabad city, Telangana State were selected. The Telangana State Hoteliers Association's was sought to have access to restaurants. The sites chosen represented a different range of commercial kitchen facilities. In this study, an air quality monitor was used to monitor parameters such as carbon dioxide, carbon monoxide and particulate matter (PM_{2.5}, PM₄ and PM₁₀) within the test kitchens. The monitor is silent, battery powered, small and capable of measuring the selected parameters on a continuous basis. The monitor was calibrated and all cells were checked before each survey was conducted, and then recalibrated and checked afterwards to account for any drift in the calibration and abnormality in the operation of the monitor. The monitor was then recharged, recalibrated and set up for the next survey.

3. Results and Discussion

Each survey was carried out for duration of at least 24 hours. All channels were logged every minute and the concentrations of these constituents measured in restaurants, catering centres and fast food centres are shown in Table 1.

3.1 Carbon dioxide (CO₂)

Carbon dioxide concentration has been used as an alternate measure of ventilation rate relative to its influence on indoor air quality [5]. Concentration of CO₂ in air was one of the parameters considered while assessing IAQ.

The acceptable CO₂ level according to the ASHRAE was below 1000 ppm which indicates that there is adequate air circulation for indoor environments. In the study it was observed that all the three cooking environments had CO₂ levels above 1000 ppm (Table 1). According to [6] CO₂ levels above 1000ppm in indoors is an indication of inadequate ventilation. High CO₂ levels can cause headaches, eye irritations in inmates.

A study results showed that inhalation of carcinogens due to improper ventilation generated during frying of meat may increase the risk of lung cancer among smokers [7]. The risk was further increased among women stir-frying meat daily whose kitchens were filled with oily fumes during cooking. [8] analyzed the association between occupation and cancer of lung and bladder in a case-control study in India. In their study, a statistically significant link between the lung cancers of cooks was found.

3.2 Carbon monoxide (CO)

This is a toxic gas emitted from appliances resulting in lung and throat cancers and reduces ability of blood to bring oxygen to body cells and tissues; cells and tissues need oxygen to work [9]. The permissible exposure level of this gas is 6ppm. In this study it was observed that restaurants,

catering centres and fast food centres indicated 7ppm, 8.8ppm and 9.4ppm respectively which are above the permissible exposure levels (Table 1).

Chao's measurements of indoor air quality showed carbon monoxide (CO) concentrations in Taiwanese are at their highest during cooking hours [10]. In Hong Kong, [11] targeted the individual exposure to CO in residences and conducted field measurements of exposure. The study showed that cooking behavior has a lot to do with one's exposure to CO, and kitchen ventilators are essential in order to get rid of the air pollutants produced in the kitchen. [12] used experiments and numerical simulations to analyze the air environment in the kitchen. [7] Investigated indoor air environment focusing on the flow fields, temperature fields and air contaminant (carbon monoxide) distributions in conventional residential kitchens, and looking for effective methods to solve those problems through natural ventilation techniques. These studies demonstrate quite clearly the health risk of cooking, where in commercial kitchens, ventilation plays an important role in providing comfortable and productive working conditions and in securing the contaminant removal.

Table 1: Mean concentration levels of Indoor air quality parameters in commercial kitchens (N=15)

Indoor Air Quality Parameters	Occupational exposure limit ASHRAE Standard*	Restaurant n=5 <i>Mean</i>	Catering centre n=5 <i>Mean</i>	Fast Food centre n=5 <i>Mean</i>
Carbon dioxide	1000 ppm	1355.432 ppm	1402.106 ppm	1334.392 ppm
Carbon monoxide	6 ppm	7 ppm	8.8 ppm	9.4 ppm
PM10	3.1 mg/m ³	2.68 mg/m ³	3.84 mg/m ³	3.58 mg/m ³
PM4	3.1 mg/m ³	2.54 mg/m ³	3.64 mg/m ³	3.06 mg/m ³
PM2.5	3.1 mg/m ³	2.56 mg/m ³	3.28 mg/m ³	3.56 mg/m ³

*ASHRAE Standard (American Society of Heating, Refrigerating and Air-Conditioning Engineers)

*ppm - Parts per million in terms of volume by volume

*mg/m³ - Milligrams per cubic metre of air

3.3 Particulate matter

Particulate matter (PM) is a complex mixture of acids (such as nitrates and sulfate), organic chemicals, metals and soil or dust particles. The size of particles is directly linked to their potential for causing health problems. Exposure to PM, total volatile organic compounds (TVOCs) and polycyclic aromatic hydrocarbons (PAHs) emissions in indoor air of commercial kitchen and presence of urinary PAHs metabolites may lead to inflammation of kidneys, which can cause microalbuminuria in kitchen workers, as observed in the study conducted by [13].

3.3.1 Particulate matter 10 (PM10)

The dust particles those less than 10 micrometers in diameter are called as (PM10) are so small that they can get into the lungs, potentially causing serious health problems [14]. They are known as respirable particulates, as they are capable of reaching the lower region of the respiratory track and are responsible for adverse health effects. Respiratory symptoms like coughing, phlegm production, wheezing, and difficulty breathing were associated with PM10 levels [15]. According

to the ASHRAE, the acceptable level of particulate matter in indoors is 3.1mg/m³.

The mean concentration of PM10 in restaurants, catering centres and fast food centres was 2.68 mg/m³, 3.84 mg/m³ and 3.58 mg/m³ respectively (Table 1). In restaurant kitchens the levels are low due to the presence of exhaust systems. In catering centres PM10 levels are found to be the highest due to the usage of fire wood. In fast food centres it was above the permissible exposure level.

Cooking with this source of fuel exposes people to the toxic fumes which contain dangerous particulate matter (PM), carbon monoxide (CO), nitrogen oxides, formaldehyde, benzene, 1,3 butadiene, polycyclic aromatic hydrocarbons (such as benzo[a]pyrene) and other toxic pollutants from the fire wood smoke [16]. Inhaling these pollutants is known to claim the lives of over 4 million people yearly world over [16] and in some sub-Saharan African countries the particulates released during cooking are responsible for up to 780/1000 deaths resulting from lung cancer, ischaemic heart disease and cardiovascular diseases combined [13]. The most common disease contracted from excessive smoke inhalation by adults is chronic obstructive pulmonary disease.

3.3.2 Particulate matter 4 (PM4)

Particulate matter of 4 micrometers in diameter is called as PM4. These particles are slightly less than PM10. These particles can get into the throat and can cause irritation in throat that may lead to continuous cough. According to the ASHRAE, the acceptable level of particulate matter in indoors is 3.1mg/m³. The mean concentration of PM4 in restaurants, catering centres and fast food centres was 2.54 mg/m³, 3.64 mg/m³ and 3.06 mg/m³ respectively (Table 1). In restaurants and fast food centres it is within the acceptable limits and in catering centres it is found to be high.

Studies carried out in Taiwan and China in recent years point out that women who accumulatively inhale kitchen oily smoke containing carcinogenic substances would be more vulnerable to lung cancer apart from chronic bronchitis and worsening of asthma. According to a survey conducted by the Chinese University of Hong Kong in, the rate of kitchen workers dying of lung cancer is 15% higher than the general public [3].

3.3.3 Particulate matter 2.5 (PM2.5)

Particulate matter of 2.5 micrometers is very fine dust that can be detected only with an electron microscope. Once these fine particles enter in the lungs, they can affect the heart, blood vessels, and lungs [17]. According to the ASHRAE, the acceptable level of particulate matter in indoors is 3.1mg/m³. The mean concentration of PM2.5 in restaurants, catering centres and fast food centres was 2.56 mg/m³, 3.28 mg/m³ and 3.56 mg/m³ respectively (Table 1). PM2.5 is found to be highest in the fast food centres as they are mainly located towards the road side pavements.

Cooking fumes, especially from frying contain fine particles (Particulate matter <2.5 µm size) and ultrafine particles (UFP) [3]. Epidemiological studies show an elevated incidence of cancers among non-smoking women with long-term exposure to cooking oil-fume [5] and an excessive bladder cancer rate among cooks exposed to kitchen air [18].

A large-scale study of personal, indoor and outdoor exposures was undertaken for more than 100 persons living in Seattle, WA, USA [19]. Based on 195 cooking events, the average PM2.5 concentration due to cooking was estimated to be 5.5 (standard error [SE], 2.3) µg/m³. As stated by [20] PM2.5 and ultrafine particles pose an even greater risk and in cities, such as Bangkok, Thailand, PM2.5 concentrations can be as much as 100 µg/m³ over 24 hours, resulting in a higher probability of contracting respiratory diseases.

4. Conclusion

The findings of this work show that the environmental conditions between different types of commercial kitchens can vary considerably. However, whilst the sample size of 15 is thought to be too small to be a representative sample population of such premises, the findings may be used as an indication of the extreme environmental conditions that the cooks could be subjected to. A larger sample population would provide a more accurate assessment of the contaminant levels and environmental conditions. Workplace risk factors and potential long-term impact of poor indoor air quality on the lives of cooks demonstrate the need for

intervention strategies viz., personal protective equipment, ergonomically designed kitchen and good ventilation systems aimed at reducing its effect on the cooks.

5. Acknowledgement

I am grateful to the management of commercial kitchens for according permission to conduct this study. I thank the authorities of Professor Jayashankar Telangana State Agricultural University and Dept. of Resource Management and Consumer Sciences for giving me an opportunity to carry out the research work and my special thanks to Dr. Mahalakshmi V. Reddy, Chairman for her guidance.

References

- [1] Svendsen K, Jensen HN, Sivertsen I, Sjaastad AK. Exposure to cooking fumes in restaurant kitchens in Norway. *Ann Occup Hyg.* 2002; 46(4):395–400. Epub 2002/08/15. PMID: 12176708.
- [2] Barr DB, Wilder LC, Caudill SP, Gonzalez AJ, Needham LL, Pirkle JL. Urinary creatinine concentrations in the U.S. population: implications for urinary biologic monitoring measurements. *Environ Health Persp.* 2005; 113(2):192–200. Epub 2005/02/03. PMID: 15687057; PubMed Central PMCID: PMC1277864.
- [3] IARC (1999). Re-evaluation of some organic chemicals, hydrazine and hydrogen peroxide. *IARC Monogr Eval Carcinog Risks Hum*, 71:1–315. PMID:10507919
- [4] IARC (2006). Formaldehyde, 2-butoxyethanol and 1-tert-butoxypropan-2-ol. *IARC Monogr Eval Carcinog Risks Hum*, 88:1–478. PMID:17366697
- [5] Biswas R, Samanta A, Saha P. Cardiac strain of confectionery worker in relation to heat exposure during regular work shift. *Indian J Occup Environ Med.* 2011; 15(3):120–6. Epub 2012/03/14. doi: 10.4103/0019-5278.93202 PMID: 22412290; PubMed Central PMCID: PMC3299096.
- [6] Evans J, Donkelaar AV, Martin RV et al. (2012). Estimates of global mortality attributable to particulate air pollution using satellite imagery. *Environ. Res.* Accessed from http://patarnott.com/satsens/pdf/globalMortalityPM_satellite.pdf. Date 12th Nov 2013.
- [7] Shields PG, Xu GX, Blot WJ et al. (1995). Mutagens from heated Chinese and U.S. cooking oils. *J Natl Cancer Inst.* 87:836–841. doi:10.1093/jnci/87.11.836. PMID:7791233
- [8] Pan CH, Chan CC, Wu KY (2008). Effects on Chinese restaurant workers of exposure to cooking oil fumes: a cautionary note on urinary 8-hydroxy-2'-deoxyguanosine. *Cancer Epidemiol Biomarkers Prev*, 17:3351–3357. doi:10.1158/1055-9965.EPI-08-0075. PMID:19064550
- [9] Luopajarvi T, Kuorinka I, Virolainen M, et al. Prevalence of tenosynovitis and other injuries of the upper extremities in repetitive work. *Scand J Work Environ Health* 1979;5:48 – 55.
- [10] Protecting the Safety and Health of Restaurant Workers <http://www.dir.ca.gov/chswc/WOSHTEP/Publications/RestaurantWorkbook.pdf>
- [11] Helander, M. 1997. The human factors profession. In *Handbook of Human Factors and Ergonomics* (G. Salvendy, ed.) pp. 3–16, John Wiley, New York, NY.

- [12] Pan CH. Profiles of musculoskeletal disorders in workers from transportation industries. *Occup Safety Health Newsletter* 1999;**35**:19 [in Chinese].
- [13] OSHA Youth Worker Safety in Restaurant - eTool <http://www.osha.gov/SLTC/youth/restaurant/index.html>
- [14] Restaurant Supervisor Safety Training Program. WOSHTEP/Commission on Health and Safety and Workers' Compensation <http://www.dir.ca.gov/chswc/SBMRMaterials.htm>
- [15] NIOSH Electrical Safety in Restaurants <http://www.cdc.gov/niosh/85-104.html>
- [16] He L-Y, Hu M, Huang X-F et al. (2004b). Measurement of emissions of fine particulate organic matter from Chinese cooking. *Atmos Environ*, 38:6557–6564. doi:10.1016/j.atmosenv.2004.08.034.
- [17] Safety on the Job is Everyone's Business http://www.worksafebc.com/publications/health_and_safety/by_topic/assets/pdf/safetyonthejob.pdf
- [18] Bindu, S.H and Reddy M.V., Occupational Health of cooks in Commercial Food Service Centres, XXV Annual Occupational Ergonomics and Safety Conference, USA, June 2013, ISBN: 97819384865-1-6
- [19] Vainiotalo S, Matveinen K (1993). Cooking fumes as a hygienic problem in the food and catering industries. *Am Ind Hyg Assoc J*, 54:376–382.
- [20] Gleeson, D., 'Health and safety in the catering industry', *Occupational Medicine*, Vol. 51 No 6, 2001, pp. 385-391.

Author Profile

E. Shirin Hima Bindu is pursuing her Ph.D from Department of Resource Management and Consumer Sciences, Prof. Jayashankar Telangana State Agricultural University. At present she is working on designing ergonomic interventions for cooks in commercial food service centres. She has also participated in national and international conferences and presented her findings.