Original Research Article

Indoor air quality and hazards associated with laundry operations in Ibadan metropolis, Nigeria

Abstract

Background and Objective: Launderers are exposed to potentially harmful chemicals during washing ironing and dyeing; exposures potentially result has negative health effects, ranging from skin and throat irritation to carcinogenicity, and negative effects on the environment.

Aims: Limited information existed on indoor air quality (IAQ) in laundry environment in developing countries especially Nigeria. This study assessed indoor air quality hazards associated with laundry operations in Ibadan metropolis, Nigeria

Materials and Methods: A descriptive cross-sectional survey was used in the study that involving a simple random selection of 50 out of 100 consenting laundry operators in five local governments, Ibadan North (IBN); Ibadan North-East (IBNE); Ibadan South-West (IBSW), Ibadan North-West (IBNW) and Ibadan South-East (IBSE).

Results: Temperature and Relative Humidity (RH) were monitored using Multi Testers N21FR. The IAQ parameters: Particulate Matters (PM_{10}) concentration, carbon dioxide (CO_2), airborne Total Bacteria Count (TBC) and Total Fungi Count (TFC) were determined using a Met One GT 321, CO_2 meter and an air sampler respectively. Measurements were taken in the morning and evening for 8 weeks. Values obtained for temperature, RH, PM_{10}, TBC and CO_2 were respectively compared with WHO limits of 26^oC, 60%, 50µg/m^3 and ≤$5x10^2$CFU/m^3 and 1,000ppm (ASHRAE)respectively.Data were analysed using descriptive statisticswith SPSS (version 20), Pearson Correlation and Chi-square at $p<0.05$.The respective mean indoor temperature (^oC), RH (%), PM_{10} ($\mu g/m^3$) and CO_2 (ppm) levels for morning across the local governments were IBN (27.4±2.5, 67.5±6.8, 7.2±1.1, 337.9±57.8); IBNE (27.5±2.0, 65.5±3.5, 7.6±9.6, 377.4±83.3); IBSW (27.6±2.3, 68.7±4.0, 7.2±0.8, 326.5±44.7); IBNW (26.8±2.6, 64.9±6.0, 7.2±9.6, 363.5±75.3) and IBSE (27.6±1.5, 64.9±3.2, 7.5±1.2, 371.6±79.6) while evening readings were IBN (28.2±2.4, 66.7±6.7, 7.2±9.6, 409.2±68.3); IBNE (28.4±2.1, 68.3±4.2, 8.0±0.9, 352.0±54.7); IBSW (28.4±1.8, 69.2±4.5, 8.0±0.8, 326.2±41.2); IBNW (28.4±2.1, 68.8±4.4, 7.8±0.9, 356.2±62.5) and IBSE (27.8±1.4, 66.3±4.2, 7.9±0.9, 352.0±54.7).The mean indoor morning TBC were 82.9±9.0, 141.4±10.2, 88.5±7.0, 163.9±12.6and 88.5±7.0in Ibadan North, Ibadan North West, Ibadan North East, Ibadan South West and Ibadan South East respectively and mean indoor afternoon TBC were 82.8±6.1, 155.7±6.3, 87.9±4.4, 183.7±8.9 and 87.9±4.4in Ibadan North, Ibadan North West, Ibadan North East, Ibadan South West and Ibadan South East respectively. Both indoor and outdoor mean total bacterial counts (TBC) CFU/m^3 values were much lower than the $\leq 5x10^2$ CFU/m^3recommended guideline limit by WHO. Indoor RH and temperature were above WHO guideline limit, while $PM_{10}$and CO_2 are below the WHO and ASHRAE guideline limit respectively and the TBC and TFC were within the WHO guideline limit in all the study locations. Therefore, improved cross ventilations are advocated to enhance indoor air quality in the laundries.

Conclusion: In laundry environment in Ibadan metropolis, Nigeria, IAQ appeared compromised. Mechanical ventilation systems in laundry environment need to be improved with respect to operation and maintenance to better maintain thermal comfort parameters and reduce levels of chemical pollutants emitted by launderers and product use during services.

Keyword: Indoor air quality, Health hazard, Laundry

1. INTRODUCTION

Clean air is a basic requirement of life [1]. Air is essential to life. It is important that human breath in good and quality air to avoid been faced with the health problems of polluted air intake. The indoor air quality can be degraded and polluted by human activities within the building and also by the nature of surrounding outdoor air. Air pollutants have several health impacts which range from mild to severe symptoms. It is important to ensure the air within buildings that are less polluted to prevent risk of exposing occupants to pollutants.

In Nigeria, there was a time a families dying overnight as a result of generator fumes. Indoor Air quantity is very significant because degradation of this quality leads to acute exposure to air pollutants within a confined area.

Air is an essential requirement for live without which living organisms would die. Quality air is essential for health. This has become a thing of concern across the globe because most human activities are carried out within buildings such as offices, schools, restaurants homes and so on. The quality of air within all buildings (laundry buildings are inclusive) should be maintained to ensure healthy living.

According to Godson et al., indoor air pollution poses health risks to all, and the severity depends on age, sex, physiological conditions and individual predisposition. Indoor air pollution usually occurs due to pollution from surrounding outdoor air, building materials and activities within the building. Ventilation is a major factor within the building upon which the severity of air pollution is dependent. Health issues associated with indoor air pollution include dizziness, sneezing, coughing, nasal congestion, wheezing, and diseases of the lungs.Evidences indicated that developing countries are at higher risk of poor indoor air quality due to poor ventilation system in most homes, buildings and inefficient cooking materials [2].

In the last several years, a growing body of scientific evidence has indicated that the air within homes and other buildings can be more seriously polluted than the outdoor air in even the largest and most industrialized cities. Other research indicates that people spend approximately 90 percent of their time indoors. Thus, for many people, the risks to health may be greater due to exposure to air pollution indoors than outdoors.

In addition, people who may be exposed to indoor air pollutants for the longest periods of time are often those most susceptible to the effects of indoor air pollution. Such groups include the young, the elderly and the chronically ill, especially those suffering from respiratory or cardiovascular disease.

Indoor Air Quality (IAQ) is an increasing concern in the world today. In fact, the mere presence of people in a building can significantly alter indoor air quality. The quality of air inside homes, offices, schools, laundry centers, public buildings, health care facilities or other private and public buildings where people spend a large part of their life is an essential determinant of healthy life and people's well-being [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15]. Problems in the indoor air of workplaces are issues which occupational health care often needs to consider when evaluating the health risks of a work environment. On the other hand, good indoor air quality has a beneficial effect on the health of employees, the social atmosphere at work, and productivity in offices. [16, 17, 18]. It was reported that up to 30% of employees in new or renovated buildings expressed an unusually high number of complaints concerning the work environment, enabling classification of the buildings as ‘‘sick’’ [19]. This appeared to be a problem especially in countries with a colder climate. Working in these problem buildings may cause respiratory symptoms (stuffy and irritated nose, rhinitis, cough, sore throat, and shortness of breath), skin symptoms, as well as general symptoms (fatigue, headache, fever), all of which are typical to the sick building syndrome (SBS) [20, 21, and 22].

Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems in several building. Inadequate ventilation in laundry environment can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources and by not carrying indoor air pollutants out of the home. High temperature and humidity levels can also increase concentrations of some pollutants. The impact of indoor air pollution on man may consist of undesired health effects of different types, ranging from sensory annoyance or discomfort to severe health injuries.

2.0 MATERIALS AND METHODS

2.1 STUDY AREA

The study area was Ibadan. Ibadan is the largest indigenous city in West Africa and is located in the South Western part of Oyo State of Nigeria. The population of central Ibadan, including five local governments; Ibadan North, Ibadan North-East, Ibadan

North-West, Ibadan South-East and Ibadan South West. LGAs, is 1 338 659 according to census results for 2006, covering an area of 128 km².

2.2 DESCRIPTION OF SAMPLING LOCATIONS

Twenty (20) laundry houses were purposefully selected from each local government area. This gave a total of 100 laundry houses from 5 Local Government areas. In each of the laundry houses, 5 respondents were randomly selected for completion of the questionnaire.

2.3 DATA COLLECTION

The study involved four methods of data collection namely air quality monitoring (Particulate matter, temperature, relative humidity, CO_2, microbial load), survey (questionnaire administration and observational checklist), laboratory analysis and statistical methods (Data management and statistical analysis). Temperature and Relative Humidity (RH) were monitored using Multi Testers N21FR. The IAQ parameters: Particulate Matters (PM_{10}) concentration, carbon dioxide (CO_2), airborne Total Bacteria Count (TBC) and Total Fungi Count (TFC) were determined using a Met One GT 321, CO_2 meter and an air sampler respectively. Values obtained for temperature, RH, PM_{10}, TBC and CO_2 were respectively compared with WHO limits of 26°C, 60%, 50µg/m^3 and ≤$5x10^2$ CFU/m^3 and 1,000ppm (ASHRAE)respectively.

2.4 DATA MANAGEMENT AND STATISTICAL ANALYSIS

Data was entered and analyzed using descriptive statistics with SPSS (version 20), Pearson Correlation and Chi-square at $p<0.05$. Descriptive statistics was used to summarize data. Mean ± Standard Deviation (SD) and range was calculated for

Temperature, Relative Humidity (RH), Particulate Matters (PM_{10}), microbial burden and carbon dioxide (CO_2) for morning and afternoon and compared with WHO guidelines of 26°C, 60%, 50µg/m^3, ≤5x10^2 CFU/m^3 and ASHRAE guideline of 1,000ppmrespectively.

3.0 RESULTS& discussion

3.1 METEOROLOGICAL PARAMETERS OF INDOOR AND OUTDOOR AIR QUALITY OF THE SELECTED LAUNDRIES

3.1.1 RELATIVE HUMIDITY (%).

The results of indoor and outdoor relative humidity of the selected laundry houses are presented in Table 1. Both the indoor and outdoor mean relative humidity (%) values were higher than the WHO recommended guideline limit of 60%.

3.1.2 TEMPERATURE READINGS (^{0}C).

The results of the indoor and outdoor temperature of the selected laundry houses are presented in Table.2.Both the indoor and outdoor mean temperature (^{0}C) values were higher than the WHO recommended guideline limit of 26^{0}C.

3.1.3 AIR CO_2 CONCENTRATION (PPM).

The results of the indoor and outdoor CO_2 concentrations of the selected laundry houses are presented in Table.3. Both the indoor and outdoor mean CO_2 concentrations (ppm) values were much lower than the ASHRAE recommendation limits of 1000ppm.

3.1.4 INDOOR CONCENTRATION OF PARTICULATE MATTER

The mean concentration for indoor PM_{10} readings (µg/m^3) for both morning and afternoon periods in the selected local governments is represented in table.4. Both the indoor and outdoor mean PM_{10} (µg/m^3) values were much lower than the WHO recommendation guideline limit of 50 µg/m^3.

Table.1: Mean Indoor and Outdoor Relative Humidity (%) across the five local governments (%)

Location		Air Relative Humidity (%)						
		Morning			Afternoon			WHO Limit
		Min	Max	Mean±SD	Min	Max	Mean±SD	
Indoor	Ibadan North	52.6	78.0	67.5±6.8	60.1	78.8	66.7±6.7	60
	Ibadan Northwest	56.1	75.1	64.9±6.0	63.3	77.9	68.8±4.4	
	Ibadan Northeast	60.8	70.8	65.5±3.5	63.2	75.6	68.3±4.2	
	Ibadan Southwest	62.7	75.6	68.7±4.0	62.5	77.0	69.2±4.5	
	Ibadan Southeast	59.0	69.0	64.9±3.2	60.9	75.1	66.3±4.2	
Outdoor	Ibadan North	58.2	77.2	66.5±5.9	55.2	63.0	60.7±2.4	
	Ibadan Northwest	59.2	73.3	66.4±3.6	58.2	69.1	65.6±3.9	
	Ibadan Northeast	55.7	77.8	66.8±5.4	57.4	68.6	64.5±3.9	
	Ibadan Southwest	58.0	78.0	67.5±6.5	57.1	68.6	62.8±3.7	
	Ibadan Southeast	57.9	75.8	66.1±4.5	55.6	66.9	62.4±4.0	

Table.2: Mean Indoor and Outdoor Temperature Readings across the five local governments (^0C)

	Location	Indoor air temperature(^0C)						
		Morning			Afternoon			WHO Limit
		Min	Max	Mean±SD	Min	Max	Mean±SD	
Indoor	Ibadan North	*24.8*	*33.7*	*27.4±2.5*	*25.5*	*34.2*	*28.2±2.4*	26
	Ibadan Northwest	*23.4*	*32.9*	*26.8±2.6*	*26.8*	*33.8*	*28.4±2.1*	
	Ibadan Northeast	*24.6*	*31.2*	*27.5±2.0*	*24.0*	*30.0*	*27.1±2.3*	
	Ibadan Southwest	*24.8*	*33.0*	*27.6±2.3*	*26.7*	*33.0*	*28.4±1.8*	
	Ibadan Southeast	*24.5*	*29.5*	*27.6±1.5*	*25.1*	*29.9*	*27.8±1.4*	
Outdoor	Ibadan North	*23.8*	*33.9*	*26.1±2.8*	*25.9*	*33.6*	*27.6±2.3*	
	Ibadan Northwest	*25.5*	*33.7*	*26.8±2.4*	*27.4*	*34.2*	*28.7±2.0*	
	Ibadan Northeast	*24.6*	*31.2*	*27.5±2.0*	*24.0*	*30.0*	*27.1±2.3*	
	Ibadan Southwest	*24.8*	*33.2*	27.1±2.5	*26.2*	*36.3*	*29.1±2.8*	
	Ibadan Southeast	*23.0*	*30.0*	*26.0±2.4*	*23.9*	*28.1*	*25.6±1.6*	

Table.3: Mean Indoor and Outdoor Air CO_2 Concentration across the five local governments (ppm).

	Location	Air CO_2 (ppm)						
		Morning			Afternoon			
		Min	Max	Mean±SD	Min	Max	Mean±SD	ASHRAE Limit
Indoor	Ibadan North	244.0	419.0	337.9±57.8	316.0	446.	355.0±45.7	1000
	Ibadan Northwest	251.5	476.0	363.5±75.3	288.0	473.	356.2±62.5	
	Ibadan Northeast	268.0	511.5	377.4±83.3	284.5	439.	352.0±54.7	
	Ibadan Southwest	257.5	378.0	326.5±44.7	260.5	393.	326.2±41.2	
	Ibadan Southeast	262.0	472.5	371.6±79.6	299.0	356.	321.7±19.8	
Outdoor	Ibadan North	240.	476.0	358.5±82.1	323.	502.	409.2±2.3	
	Ibadan Northwest	239.	394.0	327.9±56.0	330.	490.	395.5±56.3	
	Ibadan Northeast	246.	384.5	326.8±51.9	347.	380.	370.0±10.8	
	Ibadan Southwest	250.	470.5	363.6±80.8	336.	514.	424.5±66.5	
	Ibadan Southeast	240.	384.	311.3±45.5	339.	371.	355.0±10.7	

Table 4: Mean Indoor and outdoor Concentration of PM_{10}across the five local governments (μg/m^3).

	Location	Air PM_{10}(μg/m^3)						
		Morning			Afternoon			WHO limits
		Min	Max	Mean±SD	Min	Max	Mean±SD	
Indoor	Ibadan North	*6.4*	*10.3*	*7.2±1.1*	*7.2*	*9.6*	*7.2±9.6*	50
	Ibadan Northwest	*7.2*	*9.6*	*7.2±9.6*	*6.8*	*9.8*	*7.8±0.9*	
	Ibadan Northeast	*6.9*	*9.9*	*7.6±9.6*	*7.1*	*9.9*	*8.0±0.9*	
	Ibadan Southwest	*6.8*	*9.3*	*7.2±0.8*	*7.2*	*9.8*	*8.0±0.8*	
	Ibadan Southeast	*6.8*	*9.7*	*7.5±1.2*	*7.0*	*9.8*	*7.9±0.9*	
Outdoor	Ibadan North	*5.8*	*10.2*	*7.4±1.6*	*6.1*	*10.3*	*8.0±1.9*	
	Ibadan Northwest	*5.9*	*10.2*	*7.7±1.6*	*5.9*	*10.5*	*7.7±1.9*	
	Ibadan Northeast	*5.9*	*10.3*	*7.7±1.5*	*6.1*	*10.6*	*7.9±1.7*	
	Ibadan Southwest	*5.8*	*10.2*	7.6±*1.5*	*6.3*	*10.4*	*8.0±1.7*	
	Ibadan Southeast	*5.8*	*10.2*	*7.7±1.5*	*6.1*	*10.6*	*7.8±1.7*	

3.2 Microbial burden

3.2.1 Indoor and outdoor airborne Bacterial burden among five local governments.

The mean indoor and outdoor values of total bacterial counts (TBC) CFU/m^3 in the selected laundry houses are presented in table 5. Both the indoor and outdoor mean total bacterial counts (TBC) CFU/m^3 values were much lower than the $\leq 5x10^2$ CFU/m^3recommended guideline limit of the WHO standards.

4.0 CONCLUSION

In laundry environment in Ibadan metropolis, Nigeria, IAQ appeared compromised. Mechanical ventilation systems in laundry environment need to be improved with respect to operation and maintenance to maintain thermal comfort parameters and reduce levels of chemical pollutants emitted by launderers and product use during services.

Relative humidity for both indoor and outdoor in the morning and afternoon in all the laundries was above the WHO standards of 60% and this may be attributed to the fact the study was carried in Nigeria. Although the sanitary practices were good, the temperature and relative humidity were all higher than the permissible limits and these made the wastes and water to impact indoor air quality.PM_{10} of all laundries visited were significantly lower than WHO guideline limit of 50μg/m^3 and CO_2 was significantly lower than the comfort level of 1000ppm in all laundries visited as stipulated by ASHRAE. This is an indication that there is adequate ventilation in the laundries and shows that the CO_2 outdoor has a positive effect on the indoor CO_2. Indoor and outdoor meteorological factors both in the morning and afternoon exceeded the comfort level of 19^oC–26^oC and even the WHO guideline limit of 18^oC–26^oC but as a result of the weather condition in this part of the world, Nigeria precisely, the high level of temperature observed might not have any significant effect on the people in the laundry.

5.0RECOMMENDATIONS

The following recommendations are given based on the research findings and these include programs that change the behavioural patterns of the launderers;

1. Educating launderers regarding indoor air quality is a must because launderers need to be provided with the information about sources and effects of indoor air pollution under their control and about the proper operation of ventilating system that can alert their employers and/or take action to reduce their personnel expression.
2. Sources of microbial contaminants and areas where water collection and leakage had occurred (including roofs, HVAC cooling coils and fan coil unit if any) should be cleaned up appropriately. Also, prompt removal of porous organic materials (damp insulation in ventilation system, mouldy ceiling tiles, mildewed carpets) should be encouraged.
3. Routine monitoring of the indoor air quality should be carried out bi-annually in the laundry locations so as to ensure optimal work efficiency by the Environmental Health Officers Registration Council of Nigeria (EHORECON), Oyo State Chapter and National Environmental Standards and Regulations Enforcement Agency (NESREA).
4. Biocides and bacillocids should be used periodically to mop the floor of the laundry facilities so as to control bio-aerosol concentrations.

5. The association of launderers in Oyo State should enforce weekly and monthly environmental sanitation to their members in order to promote hygienic and sanitary environment.

Table 5: Mean Total Bacterial Counts (TBC) of the laundries among the five local governments(CFU/m^3).

	Location	Air microbial quality (CFU/m^3)						
		Morning			Afternoon			WHO Limit
		Min	Max	Mean±SD	Min	Max	Mean±SD	
Indoor	Ibadan North	66.5	91.0	82.9±9.0	72.5	91.0	82.8±6.1	≤5x10^2
	Ibadan Northwest	129.5	158.0	141.4±10.2	142.5	161.	155.7±6.3	
	Ibadan Northeast	79.5	98.5	88.5±7.0	79.5	95.5	87.9±4.4	
	Ibadan Southwest	147.0	188.5	163.9±12.6	169.5	196.	183.7±8.9	
	Ibadan Southeast	75.5	98.5	88.5±7.0	79.5	95.5	87.9±4.4	
Outdoor	Ibadan North	77.5	144.0	104.0±23.1	68.5	170.	120.4±4.6	
	Ibadan Northwest	132.0	180.5	153.4±16.2	144.5	181.	161.2±12.9	
	Ibadan Northeast	68.5	97.0	84.8±9.0	81.5	149.	91.9±20.0	
	Ibadan Southwest	147.0	188.5	163.9±12.6	169.5	196.	183.7±8.9	

Ibadan Southeast	79.5	98.5	88.5±7.0	79.5	95.5	87.9±4.4

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