

Original Research Article

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

Abstract

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

A descriptive cross-sectional survey involving simple random selection of 50 out of 100 consenting laundry operators in Ibadan North (IBN); Ibadan North-East (IBNE); Ibadan South-West (IBSW), Ibadan North-West (IBNW) and Ibadan South-East (IBSE) were used.

Temperature and Relative Humidity (RH) were monitored using Multi Testers N21FR. The IAQ parameters were monitored using Met One GT 321, CO₂ meter and an air sampler. Measurements were taken in the morning and evening for 8 weeks and values obtained for all parameters were compared with WHO limits of (Temp) 26°C, RH 60%, (PM₁₀) 50µg/m³, (TBC) $\leq 5 \times 10^2$ CFU/m³ and (CO₂) 1,000ppm (ASHRAE). Data were analysed using descriptive statistics with SPSS (version 20), Pearson Correlation and Chi-square at p<0.05. Both indoor and outdoor mean total bacterial counts (TBC) CFU/m³ values were much lower than the $\leq 5 \times 10^2$ CFU/m³ recommended 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.

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. Unpolluted air quality is needed to promote human health. 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. The risk of exposing occupants in any buildings to polluted air is high when exposed to contaminated air.

An incidence occurred in Nigeria, where families died 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.

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[2]. 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[3]. Report showed 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[3]. Other research indicates that people spend approximately 90 percent of their time indoors[2]. 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[2].

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]. Thus, 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 space. 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. Therefore, assessing the indoor air quality and hazards associated with laundry operations in Ibadan metropolis, Nigeria is essential.

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. The latitude of Ibadan, Nigeria is 7.376736, and the longitude is 3.939786. Ibadan, the capital of Oyo State is located at Nigeria country in the Cities place category with the GPS coordinates of 7° 22' 36.2496" N and 3° 56' 23.2296" E. Ibadan has a tropical wet and dry climate with a lengthy wet season and relatively constant temperatures throughout the year. Ibadan's wet season runs from March through October, though August sees somewhat of a lull in precipitation [23 and 24].

2.2 DESCRIPTION OF SAMPLING LOCATIONS

Twenty (20) laundry houses consisting of ten (10) peoples each were purposefully selected from each local government area. This gave a total of 100 laundry houses and one thousand (1000) peoples from 5 Local Government areas. In each of the laundry

houses, 5 respondents were randomly selected (i.e. 100 respondents) for completion of the questionnaire.

3.0 MATERIALS AND METHODS

This section comprises the materials and methods used in carrying out the research work.

3.1 DATA COLLECTION

The study involved four methods of data collection namely air quality monitoring (Particulate matter, temperature, relative humidity, CO₂, 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 (PM₁₀) concentration, carbon dioxide (CO₂), airborne Total Bacteria Count (TBC) and Total Fungi Count (TFC) were determined using a Met One GT 321, CO₂ meter and an air sampler respectively. Values obtained for temperature, RH, PM₁₀, TBC and CO₂ were respectively compared with WHO limits of 26°C, 60%, 50µg/m³ and ≤5x10² CFU/m³ and 1,000ppm (ASHRAE) respectively.

3.2 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 (PM₁₀), microbial burden and carbon dioxide (CO₂) for morning and afternoon and compared with WHO guidelines of 26°C, 60%, 50µg/m³, ≤5x10² CFU/m³ and ASHRAE guideline of 1,000ppm respectively.

4.0 RESULTS AND DISCUSSION

Results obtained during the research works were displaced here and explanation based on the results obtained were also discussed in this section.

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

4.1.1 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, clean air act (CAA) of United Nations of Environmental Protection Agency (UNEP), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD) and the National Health and Medical Research Council (NHMRC) recommended guideline limit of 60%.

4.1.2 TEMPERATURE READINGS (°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 (°C) values were higher than the WHO, clean air act (CAA) of United Nations of Environmental Protection Agency (UNEP), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection

Department (HKEPD) and the National Health and Medical Research Council (NHMRC) recommended guideline limit of 26⁰C.

4.1.3 AIR CO₂ CONCENTRATION (PPM).

The results of the indoor and outdoor CO₂ concentrations of the selected laundry houses are presented in Table.3. Both the indoor and outdoor mean CO₂ concentrations (ppm) values were much lower than the ASHRAE recommendation limits of 1000ppm.

4.1.4 INDOOR CONCENTRATION OF PARTICULATE MATTER

The mean concentration for indoor PM₁₀ readings ($\mu\text{g}/\text{m}^3$) for both morning and afternoon periods in the selected local governments is represented in table.4. Both the indoor and outdoor mean PM₁₀ ($\mu\text{g}/\text{m}^3$) values were much lower than the WHO, clean air act (CAA) of United Nations of Environmental Protection Agency (UNEPA), American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD) and the National Health and Medical Research Council (NHMRC) recommendation guideline limit of 50 $\mu\text{g}/\text{m}^3$.

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

	Location	Air Relative Humidity (%)						WHO Limit
		Morning			Afternoon			
		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(⁰ C)						WHO Limit
		Morning			Afternoon			
		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 CO₂ Concentration across the five local governments (ppm).

	Location	Air CO ₂ (ppm)						ASHRAE Limit
		Morning			Afternoon			
		Min	Max	Mean±SD	Min	Max	Mean±SD	
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 PM₁₀ across the five local governments (µg/m³).

	Location	Air PM ₁₀ (µg/m ³)						WHO limits
		Morning			Afternoon			
		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	

Table 5: Mean Total Bacterial Counts (TBC) of the laundries among the five local governments(CFU/m³).

	Location	Air microbial quality (CFU/m ³)						WHO Limit
		Morning			Afternoon			
		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	

4.2 Microbial burden

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

The mean indoor and outdoor values of total bacterial counts (TBC) CFU/m³ in the selected laundry houses are presented in table 5. Both the indoor and outdoor mean total bacterial counts (TBC) CFU/m³ values were much lower than the $\leq 5 \times 10^2$ CFU/m³ recommended guideline limit of the WHO, clean air act (CAA) of United Nations of Environmental Protection Agency (UNEPA), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD) and the National Health and Medical Research Council (NHMRC) standards.

5.0 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, clean air act (CAA) of United Nations of Environmental Protection Agency (UNEPA), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD) and the National Health and Medical Research Council (NHMRC) 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. PM₁₀ of all laundries visited were significantly lower than WHO, clean air act (CAA) of United

Nations of Environmental Protection Agency (UNEP), American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD) and the National Health and Medical Research Council (NHMRC) guideline limit of $50\mu\text{g}/\text{m}^3$ 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°C – 26°C and even the WHO, clean air act (CAA) of United Nations of Environmental Protection Agency (UNEP), American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE), the Hong Kong Environmental Protection Department (HKEPD) and the National Health and Medical Research Council (NHMRC) guideline limit of 18°C – 26°C 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 [25].

6.0 RECOMMENDATIONS

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

1. The sources and effects of indoor air pollution where launderers are working should be known to them in order to know the proper operation of ventilating system that can affect them and/or take action to reduce their personnel expression.
2. Appropriate cleaning of any sources of microbial contaminants and areas where water collection and leakage had occurred (including roofs, HVAC cooling coils and fan coil unit if any) are important. Also, prompt removal of porous organic materials (damp insulation in ventilation system, mouldy ceiling tiles, mildewed carpets) should be encouraged.

3. Bi-annual routine monitoring of the indoor air quality should be carried out in the laundry locations by the personnel of Environmental Health Officers Registration Council of Nigeria (EHORECON), Oyo State Chapter and National Environmental Standards and Regulations Enforcement Agency (NESREA) so as to ensure optimal work efficiency
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.

UNDER PEER REVIEW

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UNDER PEER REVIEW