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Research article

Assessment of Indoor Air Pollutants Exposure in Hair Salons of Lahore

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Abstract Hairdressing activities release indoor air pollutants which are hazardous for human health. The present study was, therefore, conducted to determine indoor air pollutants exposure in hair salons of Lahore. The study period was from August to September 2019. Four hair salons were selected for sampling the indoor air pollutants during working hours and before it. Total working employees, working area, clients per day and ventilation facilities were noted on a designed proforma. The parameters of indoor air pollutants included volatile organic compounds (VOCs), coarse particulate matter (PM_{10}), ozone (O_3), carbon dioxide (CO_2), relative humidity (RH%) and temperature (°C). PM_{10} was monitored through DustTrak aerosol monitors (model 8520, TSI Inc.). Similarly, VOCs, O_3, RH% and temperature were measured through a portable aeroqual series 500 after using relevant sensors. The sampling period for all pollutants were 8-hours. The concentration levels of VOCs, O_3 and PM_{10} were higher during working hours as compared to the before. Only the level of in all selected hair salons was above the recommended exposure limits (> 0.20-0.50 ppm). The ventilation system was insufficient. Indoor air pollutants exposure level in hair salons was higher during working hours as compared to the before. However, all pollutants were within the prescribed exposure limits except VOCs. Uses of less hazardous chemical products, regular biological monitoring, and proper ventilation system along with large sample size of hair salons are recommended for further studies.

Keywords: Particulate matter, Environmental pollutants, Volatile organic compounds, Ozone, Carbon dioxide

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INTRODUCTION

Hairdressing has become in demand profession all over the world contemporarily. Due to the semi-closed environment and cosmetic products used in the hair salon, indoor air quality (IAQ) is being highlighted by the researchers to secure public health (Taiwan MOL, 2014).

Different hair-care activities such as washing hair with shampoo, lotions and powder; hairstyling with gel, creams, and lacquers; changing the hair shaping and colour through waving and straightening creams, bleach and dyes release air pollutants in the air of hair salons (de Gennaro et al., 2014; Kaikiti et al., 2022). These air pollutants include particulate matter (PM), volatile organic compounds (VOCs), ozone, and carbon monoxide (CO) and carbon dioxide (CO_2) etc. (Tsigonia et al., 2010; Hadei et al., 2018; Kaikiti et al., 2022). Different factors such as types and frequency of services offered and applications of beauty products in salons pose notable effects on the concentration levels of indoor PM, VOCs, and CO_2 (Tsigonia et al., 2010; Rogula-Kopiec et al., 2019).

Hair salons are usually poorly ventilated; therefore, air pollutants accumulate inside and may affect public health (Chang et al., 2017). These pollutants remain air born inside of hair salons, therefore compromise indoor air and environment quality (IEQ) (Moscato et al., 2005). It is evident from previous researches that high concentrations level of indoor CO_2, PM and VOCs affects the easement, health and worker's performance in beauty salons (Goldin et al., 2014; Ana et al., 2019). These pollutants enter the human body through the skin and breathing process (Liteplo and Meek, 2003) causing skin problems, respiratory illnesses, reproductive problems, musculo-skeletal strain disorders, headache, nausea etc. (de Gennaro et al., 2014; Mainka and Zajusz-Zubek, 2015; Begambo and Saria, 2016; Tagesse et al., 2021). The authors do not know any work done in Pakistan related to the indoor air quality in hair salons. The present study was, therefore, conducted to observe exposure levels through differences in indoor air pollutants concentrations during working hours and before it. Second purpose was to determine indoor air pollutants compliance with guidelines set by different international agencies/institutes for indoor environments.

MATERIALS AND METHODS

Selection of salons

In the present study, 10 hair salons were aimed to study. The sample size was calculated using the G Power formula proposed by Faul et al., (2007).However, due to the days of pandemic, limited operational saloons were working. Therefore, a total of four hair salons in Lahore were investigated through a convenience sampling method. To reduce the impact of outdoor air pollution, salons were selected far from the heavily polluted city centre areas. Such areas are industrial sites, biomass burning, coal combustion, resuspended road/soil dust, and vehicular emissions. Industrial dust is the highest contributor (23.2%) (Shahid et al., 2018). The salons were located far from the main road of heavy traffic as well. The study duration was from August to September 2019.

A performa was designed to get information regarding total working employees, an average number of clients per day, work area measurement, and ventilation facilities in all four salons.

Bioethical clearance certificate

Bioethical clearance certificate was obtained through the departmental ethical committee of University of Punjab, Pakistan.

Measurement of indoor air quality

Indoor air pollutants were measured before and after working hours to assess the differences in recorded measurements. Coarse Particulate matter (PM_{10}) was monitored through DustTrak aerosol monitors (model 8520, TSI Inc.), in all four salons. Similarly, Volatile organic compounds (VOCs), and ozone (O_3) were measured through a portable aeroqual series 500 after using relevant sensors. However, carbon dioxide (CO_2), relative humidity in percentage (RH %) and temperature in Celsius (C°) were also measured through the same device during working hours only. The sampling duration for all air pollutants were 8-hours. The sampler was placed near the working area at a height of 1.5m above. Smoking was not allowed during the monitoring period and even after that.

Standard guidelines for air pollutants

Different standard guidelines were used to compare the results of the present study. The concentration level of VOCs was compared with the guidelines of the United States Environmental protection agency (US EPA, 2016). While O_3 and PM_{10} were in contrast with the guidelines of the Environment Protection Department (EPA Punjab, 2016). Moreover, CO_2, RH%, and temperature were compared with the standards set by Occupational Safety and Health Administration (OSHA, 2011), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 62.1-2016, and ASHRAE Standard 55-2017, respectively.

Analysis of data

Data were analyzed statistically using SPSS (version 25). Data were compared between working hours and before working hours to assess differences in pollutant values through paired sample t-test. Finally, all measured values of indoor pollutants were compared with the standard exposure limit values recommended by different international agencies/institutes. The P-value of up to 0.05 was considered statistically significant.

RESULTS

In the present study, the average salon area with working employees was 23m2 and 05, respectively. Similarly, the average total clients per day, RH%, temperature and CO_2 level were 13, 46.9%, 20.3C° and 3149.1 ppm, respectively. Mean and standard deviation of indoor environmental characteristics of Hair Salons were determined. Moreover, the ventilation system was skimpy in all selected salons. In all salons except one, windows were closed throughout the working hours with the purpose to maintain the cooling of AC units (Table 1).

Table 1. Indoor environmental characteristics of hair salons.

Characteristics	Salon A	Salon B	Salon C	Salon D
Employees count	4.00 ± 1.87	2.00 ± 1.00	2.00 ± 1.00	3.00 ± 1.29
Clients per day	6.00 ± 3.31	8.00 ± 3.02	8.00 ± 3.02	6.00 ± 3.31
Work area (m^2)	15.00 ± 0.57	9.00 ± 1.63	11.00 ± 1.42	6.00 ± 1.11
Ventilation	Window & AC unit*	Window & AC unit	Window & Fans	Window & AC unit
RH (%)	43.63 ± 2.27	40.73 ± 2.16	56.58 ± 1.16	43.44 ± 2.38
Temperature (C°)	21.00 ± 1.11	16.00 ± 2.21	22 ± 2.08	17.00 ± 1.85
CO_2 (ppm)	3200.88 ± 4.20	3900.10 ± 5.50	3376.10 ± 4.80	1940.16 ± 3.90

Note: Data indicated as Mean± SD; *AC: Air conditioner

The indoor concentration level of VOCs and O_3 was measured during working hours and before working hours and their mean values were mentioned in Table 2.

In all selected salons, a significant mean difference exist in VOCs values before and during the working hours with $P = 0.000$. These values were higher during working hours. Similarly, the concentration level of PM_{10} was noted with two different measurement times, during working hours and before it. The mean values were calculated and showed in Table 3. In all salons, the mean value of PM_{10} showed significant difference with $P = 0.000$. The concentration level of PM_{10} was comparatively higher during working hours than before it, in all selected salons.

Table 2. Measurements of ozone (O_3) and volatile organic compounds (VOCs) in selected hair salons.

Hair Salon	Measurement	O_3 (ppm)	VOCs (ppm)
A	Before	0.01 ± 0.001	0.24 ± 0.01
	After	0.02 ± 0.001	2.15 ± 0.96
B	Before	0.04 ± 0.001	0.25 ± 0.01
	After	0.04 ± 0.005	3.48 ± 0.39
C	Before	0.03 ± 0.009	0.30 ± 0.03
	After	0.07 ± 0.005	1.00 ± 0.33
D	Before	0.03 ± 0.001	0.41 ± 0.068
	After	0.05 ± 0.005	2.25 ± 1.31
Sig.		0.000***	0.000***

Note: Data indicated as Mean± SD; ***. = $P < 0.05$

Table 3. Measurements of PM_{10} (μg/m^3) in selected hair salons.

Measurements	Hair Salons				Sig.
	A	B	C	D	
Before work	117.45 ± 1.87	129.80 ± 0.38	138.88 ± 0.36	102.73 ± 1.26	0.000***
During work	148.03 ± 10.26	141.17 ± 8.79	143.11 ± 1.46	113.11 ± 4.92	

Note: Data indicated as Mean ± SD, ***. = $P < 0.05$

The measured concentration values of all indoor pollutants were compared with the guidelines recommended by different international agencies/institutes (Table 4). The level of VOCs was above the recommended exposure limit except for O_3, PM_{10}, CO_2, RH % and temperature.

Table 4. Indoor air pollutants of selected Hair salons with exposure limit.

Air pollutants	Guideline	Concentrations range		Exposure Limit
O_3	[a]130 μg/m^3(0.00013 ppm)	Salon A-D	0.02-0.07 ppm	Above limit
VOCs	[b]500 μg/m^3(0.20-0.50 ppm)	Salon A-D	1.00-3.48 ppm	Above limit
PM_{10}	[a]150 μg/m^3	Salon A-D	113.11-148.03 μg/m^3	Within limit
CO_2	[c]5000 ppm	Salon A-D	1980.06-3986.13 ppm	Within limit
RH (%)	[d] < 65%	Salon A-D	41.75-57.25 %	Within limit
Temperature (C°)	[e]67-82F°(19.4-27.7 C°)	Salon A-D	17-24 C°	Within limit

Note: [a] EPA Punjab (2016), [b] US EPA (2016), [c] OSHA (2011), [d] ASHRAE Standard 62.1-2016, [e] ASHRAE Standard 55-2017

DISCUSSION

The concentration level of VOCs exposure was greater during working hours as compared to before. The range was recorded from 1.00 to 3.48 ppm, in working hours. It was found that a significant mean difference exist in VOCs values before

and during the working hours with P = 0.000. The results are in agreement with Acharya et al. (2020). They assessed the indoor air pollutants in hair salons of South Korea and concluded that the concentration level of VOCs in all selected salons was higher during working hours than before. All monitored values were ranged from 0.54 to 4.10 ppm. Similarly, when compared with the guidelines recommended by US EPA (2016), the VOCs values were higher than 0.20-0.50 ppm in all selected salons of the present study. On the other hand, clinical studies proved that VOCs exposure in hair salons increase the level of serum C-reactive protein (CRP) and 8-hydroxy-2#-deoxyguanosine (8-OHdG) as well as decreases in HRV indices. These effects were reduced when away from work and further consolidate the findings of the present study (Ma et al., 2010). The concentration level of VOCs may be contributed by the nature of products used in hair salons while per customer area used and ventilation are less involved in VOCs level (de Gennaro et al., 2014).

Similarly, the concentration level of O_3 exposure was higher during working hours and ranged from 0.02 to 0.07 ppm. Tsigonia et al. (2010) investigated the indoor air pollution and occupational exposure of beauty salons in Greece. They measured the range of O_3 concentration as 0.4 to 1 ppm, which is higher than the present findings. After comparing with the guidelines of O_3 (0.00013 ppm), the current finding was within the standard guideline limit (EPA-Punjab, 2016). However, it seems that even after using steam equipment in hair salons, the ozone concentration does not rise to the harmful level and on that account, hairdressers less likely to be exposed to the high concentration level of ozone in beauty salons.

The concentration level of PM_{10} exposure was higher during working hours than before. High concentration levels of PM_{10}, VOCs, and CO_2 during working hours may be due to the types and frequency of services offered, numbers of people in the salon and applications of beauty products in salons (Tsigonia et al., 2010; Ana et al., 2019; Rogula-Kopiec et al., 2019). Moreover, it has also been found that an increased level of VOCs may lead high concentration level of PM_{10}. A similar positive correlation was reported between CO_2 and PM_{10} (Ana et al., 2019). However, values of PM_{10} concentration in all four salons were within the limits of standard guidelines of PM_{10} (150 $\mu g/m^3$) (EPA-Punjab, 2016). A similar finding was also reported by Acharya et al. (2020) in a hair salon where the concentration level of PM_{10} was below the standard limit.

Finally, the level of CO_2 concentration, RH% and temperature were within the limit of standard guidelines maintained by OSHA (2011), ASHRAE Standard 62.1 (2016) and ASHRAE Standard 55 (2017), respectively. The level of CO2 is not usually involved in health impact, however, declared as an important index of indoor air quality. Its concentration level is influenced by the number of individuals and air changes rate (Tsigonia et al., 2010). Temperature and RH% play a significant role to keep a high concentration level of indoor air pollutants in the room air. High humidity prevents VOCs to attach to the surfaces of dust or residential objects (Bentayeb et al., 2015; Zhou et al., 2017). Similarly, high temperature vaporizes the components of hairdressing products; hence increase the exposure level (OSHA 2011). Ventilation is an important contributor to maintain the indoor air quality in beauty salons (Labreche et al., 2003; Ronda et al., 2009). In the present research, the ventilation system was inappropriate. Windows, fans and ac units were installed for ventilation but windows were closed during working hours that gather indoor air pollutants in the salons.

CONCLUSION

In hair salons, the concentrations level of VOCs, O_3, and PM_{10} were relatively higher during working hours as compared to before. The concentration level of VOCs was comparatively above the guidelines exposure limits of international institutes/agencies. The ventilation system was insufficient. The uses of less hazardous chemical products, biological monitoring and large sample size along with proper ventilation system are recommended to reduce the impact of indoor air pollutants exposure in hair salons.

LIMITATIONS

In present study, population was unknown and that was basic limitation in this study. Result outcomes may be biased. Moreover, when sample was collected, it was in days of pandemic, majority of salons were closed by government as they failed to follow SOPs so only those salons were approached that were operational.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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