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IoT-Based Air Quality Monitoring in Hair Salons: Screening of Hazardous Air Pollutants Based on Personal Exposure and Health Risk Assessment

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Abstract Hair salons use many hair products that have toxic chemicals in them. These toxic chemicals include volatile organic compounds, formaldehyde, and particulate matter. Daily exposure to these pollutants causes severe health issues in the long run. This study aims to find the concentration of the air pollutants such as PM_1, $PM_{2.5}$, PM_{10}, TVOC, CO_2, and formaldehyde in four hair salons located in Coimbatore, Tamil Nadu, India. In this paper, we propose an IoT-based air quality monitoring system with integrated sensors to monitor the concentration of air pollutants remotely via ThingSpeak data analytics cloud platform in hair salons. The maximum 15 min average concentration values of PM1, PM2.5, and PM10 were 128, 154, and 169 µg/m3 respectively. The TVOC levels exhibited a rapid increase of about 80–90% during facials and hair gel application and a peak value of about 5248.25 ppb was measured at salon 2. Also, weekend and weekday comparison is done. It was found that the weekend concentrations of the measured pollutants are comparatively higher than weekday concentrations. After analyzing the pollutant concentration, the effects of primary health parameters such as blood pressure and pulse rate of the hairdressers are measured. One-third of the hairdressers displayed high blood pressure values with a maximum of 161/104 which falls under stage 2 hypertension. Also, secondary parameters such as temperature, humidity, ventilation type, and number of customers are also measured. From the overall analysis, it is suggested that adequate ventilation and regulated product usage are said to reduce the effects of indoor air pollution.

Keywords Air pollution · Internet of Things (IoT) · ThingSpeak cloud platform · Personal exposure · Hair salon · Health risk assessment

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1 Introduction

Air pollution is one of the significant health concerning areas, out of which indoor air pollution plays a potential role in causing health hazards (Gautam et al., 2016; Kumar et al., 2022; Masih et al., 2019; Sahu et al., 2018). One such contributor to indoor air pollution is hair salons. In India, the salon industry has grown exponentially in recent decades. Hair salons use

many hair products for various treatments such as hair straightening, smoothening, and spa treatments (Leino et al., 1999). These hair and cosmetic products are of concern due to their toxicants. While any such hair treatment process, like hair straightening, is carried out, toxicants like formaldehyde in the solution are released into the atmosphere. This serves as a potential source of concerning indoor air pollution. Some hazardous air pollutants in hair salons are volatile organic compounds (VOCs) present in aromatics, formaldehyde, and particulate matter (PM) that are present in hair products and also result from processes such as hair cutting and trimming. When the associated hairdressers and customers inhale or come in contact with these air pollutants, they might encounter severe health hazards in the long run. Especially hairdressers exposed to these pollutants daily are more prone to health issues. Skin and respiratory disorders, carcinogenicity, and reproductive and genotoxic effects have been associated with compounds released in beauty salons (Galiotte et al., 2008; Halliday-Bell et al., 2009). Therefore, analysis of such environments must be assessed for their high-risk potential and associated health hazards.

Benzene, toluene, ethylbenzene, and xylene (BTEX compounds) are some of the most common VOCs. Among these BTEX compounds, benzene and ethylbenzene are considered to be carcinogenic, also causing respiratory issues (World Health Organization). Toluene and xylene are said to damage the nervous and reproductive systems. The Integrated Risk Information System (IRIS) under the United States Environmental Protection Agency (EPA) has classified formaldehyde as a probable human carcinogen (group B1) (U.S.EPA. Integrated Risk Information System, IRIS, n.d.). The International Agency for Research on Cancer (IARC) has classified formaldehyde as a human carcinogen (group 1) (IARC). Studies (Isinkaralar, 2022a, b) show that BTEX in indoor air can be reduced either by filtration or ventilation. Moreover, promising researches (Isinkaralar & Turkyilmaz, 2022; Istanbullu et al., 2023) have been proceeded to reduce the BTEX concentration by using high surface area activated carbon exposure to ambient delicate particulate matter with an aerodynamic diameter of < 2.5 microns (PM2.5) which has been considered as an environmental hazard (Lee et al., 2020). Continuous and long-term exposure to PM1 can cause severe health and respiratory issues. PM1 and PM10 do not have any specific safe levels but their long-term exposure affects human health.

Many studies have been carried out to identify the potential risks associated with hair salons, and only a few have focused on particulate matter (Kaikiti et al., 2022). Also, studies have shown reported outcomes, but the relationship between pollutants and the associated hair treatment techniques needs to be better established (Hadei et al., n.d.). The novelty of the proposed work is to aggregate the various air pollutants (PM1, PM2.5, PM10, HCHO, TVOC, CO2) with the help of sensors (CAIR + smart indoor air quality sensor and SGP30 sensor) and WeMos microcontrollers and monitor them using IoT data analytics ThingSpeak cloud platform.

Since the conventional method of air quality monitoring requires the involvement of heavy, bulk equipments, the IoT-based sensors are light and compact and have less power consumption. With the advancement of technology, Internet of Things plays a remarkable role as a global computing network by connecting everything to the internet (Khan et al., 2012). This system sends the data obtained from any device with sensors to already existing internet platforms (Zeng, 2012). IoT has multiple applications in fields such as environmental monitoring, military, disaster monitoring, home automation, healthcare, agriculture, and transportation (Ashok et al., 2023; Selvadass et al., 2022; Ramson et al., 2020). Numerous studies (Ayele & Mehta, 2018; Shah & Mishra, 2016; Raipure & Mehetre, 2015; Sumithra et al., 2016; Taneja et al., 2017) carried out in India with the application of IoT in air quality monitoring proved to be accurate and reliable with precise information. Studies (Xiaojun et al., 2015) show that the hardware cost is reduced to 1/10th of before after incorporating IoT in air quality monitoring. The IoT system comprises a perception layer, network layer, and application layer wherein the sensors come under the perception layer (Xiaojun et al., 2015). In this context, the SGP30 air quality sensor is located at the monitoring point within the perception layer. In the network layer, the air quality data is transmitted from the sensor to the IoT data analytics platform called Thing Speak which depicts the data in graphical format (Maureira et al., 2014).

Establishing a clear relationship between the pollutants and hair treatment techniques is essential to determine the associated health risk potential. Only then the mitigation measures that can be adopted for better IAQ can be suggested. This might pave the way for

establishing future cosmetic and hair salon regulations. The results of this study highlight the pollutant concentration level associated with specific hair treatment techniques, which can be used to adopt suitable mitigation measures. The pollutants taken into consideration are benzene, toluene, ethyl benzene, xylene, formaldehyde, PM1, PM2.5, PM10, and CO2 in four hair salons and their concentrations to the different environmental and occupational characteristics of hair salons.

2 Methodology

2.1 Study Area

Coimbatore (11.0168° N, 76.9558° E), one of the South Indian cities in Tamil Nadu, has been chosen as the sampling area for assessing the indoor air quality in hair salons (Fig. 1). It is the third largest metropolitan city in the State Tamil Nadu, India. Sampling was done in a total of four salons out of which three salons are located in Karunya Nagar, Coimbatore, which is a rural place and one in P.N Palayam, Coimbatore, located right at the city center. In both men's and ladies' hair/beauty salons, the health effects of air pollutants on the hairdressers are studied.

2.1.1 Study Design

This study uses sensor technology to monitor the indoor air quality of hair salons. The proposed prototype comprises two sections: the transmitter and the receiver unit. The transmitter unit includes the sensors and microcontrollers, whereas the receiver end has the ThingSpeak cloud computing platform (Fig. 2). The SGP30 Multi-pixel gas air quality sensor is interfaced with the WeMos microcontroller. WeMos microcontroller consumes less power (3.3 V) with high processing capability and is compact in size. The advantage of the inbuilt ESP8266 Wi-Fi module

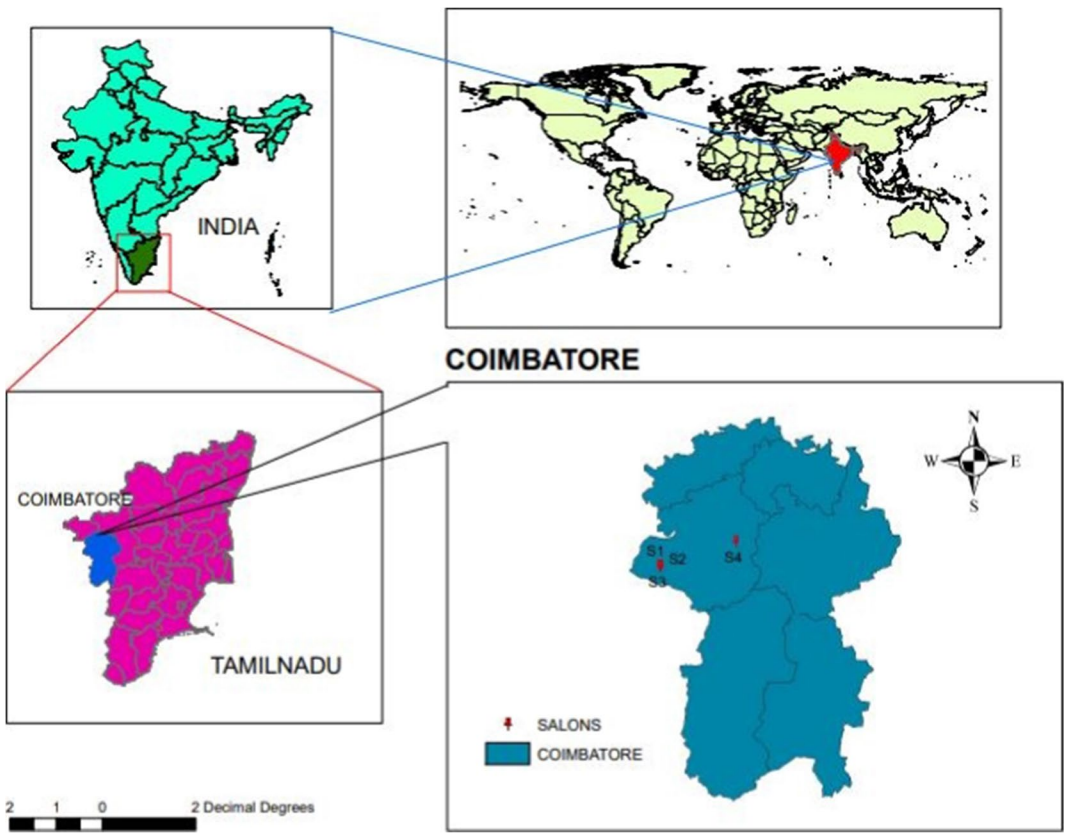


Fig. 1 Map of the study area–Coimbatore, Tamil Nadu, India

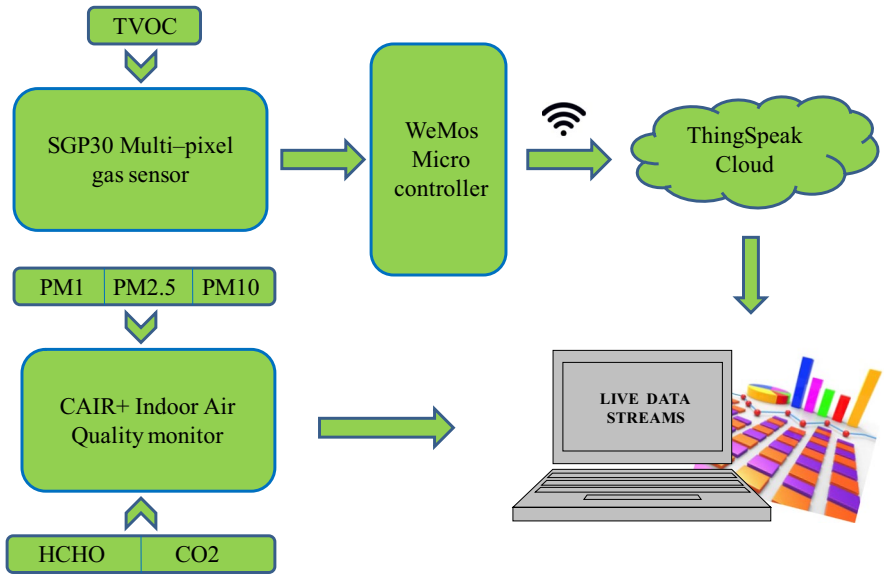


Fig. 2 Block diagram of the proposed prototype

is it enables connection to the internet directly which facilitates the collected TVOC values to upload and analyze the parameters using the ThingSpeak cloud analytics platform. Also, the CAIR + Indoor Air quality monitor acquires PM1, PM2.5, PM10, HCHO, and TVOC values in an SD card.

The sampling was done in four salons located in different areas of Coimbatore. Several parameters were observed during the sampling period. Those parameters include temperature, humidity, number of customers, active employees, surface area, and type of ongoing treatments. Smoking was prohibited in all four salons. The concentration of the pollutants was recorded using air quality sensors.

The concentration of the following air pollutants was recorded. The concentration of particulate matter with an aerodynamic diameter of fewer than 1 microns, 2.5 microns, and 10 microns was recorded using a CAIR + Smart Indoor Air quality monitor. The concentrations of carbon dioxide (CO2), formaldehyde (HCHO), temperature, and humidity are also recorded along with the particulate matter. The total volatile organic compounds (TVOC) concentration is measured using SGP30 Multi–pixel gas sensor, a fully integrated MOX gas sensor. The SGP30 sensor is made by Sensirion and is the first metaoxide gas sensor with multiple sensors on the same chip (Rüffer et al., 2018). This excellent air quality sensor with I2C interfacing gives fully calibrated output signals with a typical accuracy of 15% within measured values. The SGP combines multiple metal-oxide sensing elements on one chip to provide more detailed air quality signals. Studies (Yurko et al., 2019) show that the SGP30 sensors provide the most consistent results for all VOC hydrocarbons. The SGP30 sensor is set up by connecting to the WeMos microcontroller.

Figure 3 shows the connection setup for the SGP30 Multi-pixel gas sensor with the WeMos microcontroller via I2C. The I2C (inter-integrated circuit) is a master–slave communication protocol, where the output bits are synchronized with the clock signal. Multiple slaves can be connected and controlled by a single master. Each slave device has a unique 7- or 10-bit address. The slave address (SPG30) in this case is 0×58. I2C has two pins SDA and SCL. The TVOC values from the SPG30 sensor are transmitted through a single SDA line to the microcontroller. Once the TVOC values are received, pre-processing and filtering of noise or unwanted values are done. This data pre-processing is done to ensure that only defined TVOC values are uploaded to the ThingSpeak cloud. The overall process flow from instrument setup to statistical analysis is shown in Fig. 4.

The health parameters such as systolic blood pressure, diastolic blood pressure, and pulse rate were measured using OMRON HEM – 7121 J upper arm blood pressure monitor. The monitor adopts the

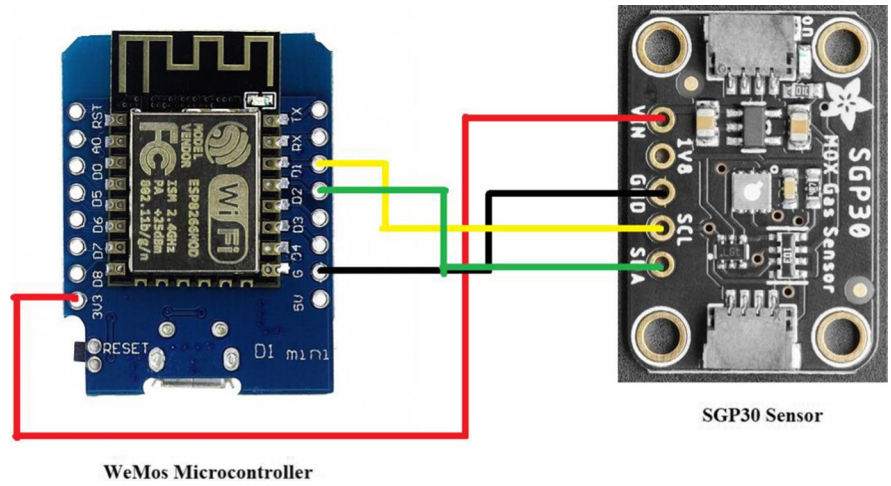


Fig. 3 Connection diagram of SGP30 sensor

WeMos	SPG30 sensor
3v3 (3.3V)	Vin
G	GND
D1	SCL
D2	SDA

oscillometric measurement method. The pressure readings and pulse accuracy are ± 3 mm Hg and ± 5% of the display reading, respectively.

2.1.2 Data Collection

Data collection was carried out between October and November 2022. A standard sampling duration of 6 h was adopted. The CAIR + Smart Indoor Air quality monitor and the SGP30 gas sensor were placed near the working station of the hair salons (Fig. 5). The sampling took place for 2 days in each salon. One sample was taken during the weekday and the other during the weekend. Based on gender criteria, the selected hair salon comprises two men's and two ladies' hair salons. This covers the different types of hair treatments taking place in hair salons. The observed hair and beauty treatments include haircuts and styling, hair coloring, hair spa, threading, and facials. The ventilation type of the hair and beauty salons was also observed.

In order to find the impacts of air pollutants on health effects, the blood pressure (mmHg) and the pulse (rate/min) are measured for the employees. The blood pressure and pulse rate are measured for the employees when they are at rest (before work) and when they have completed their hair treatments for customers (after work). Other parameters such as surface area, number of active cosmetologists, type of ongoing treatments, and number of customers were also observed.

2.1.3 Statistical Analysis

All the statistical analysis was performed using Python and Excel. The Shapiro–Wilk test was used to check the normality of the data. The correlations between the concentrations of the measured pollutants were assessed with Spearman's correlation. The relationship between the temperature, relative humidity, and the measured concentration of pollutants was analyzed using simple linear regression.

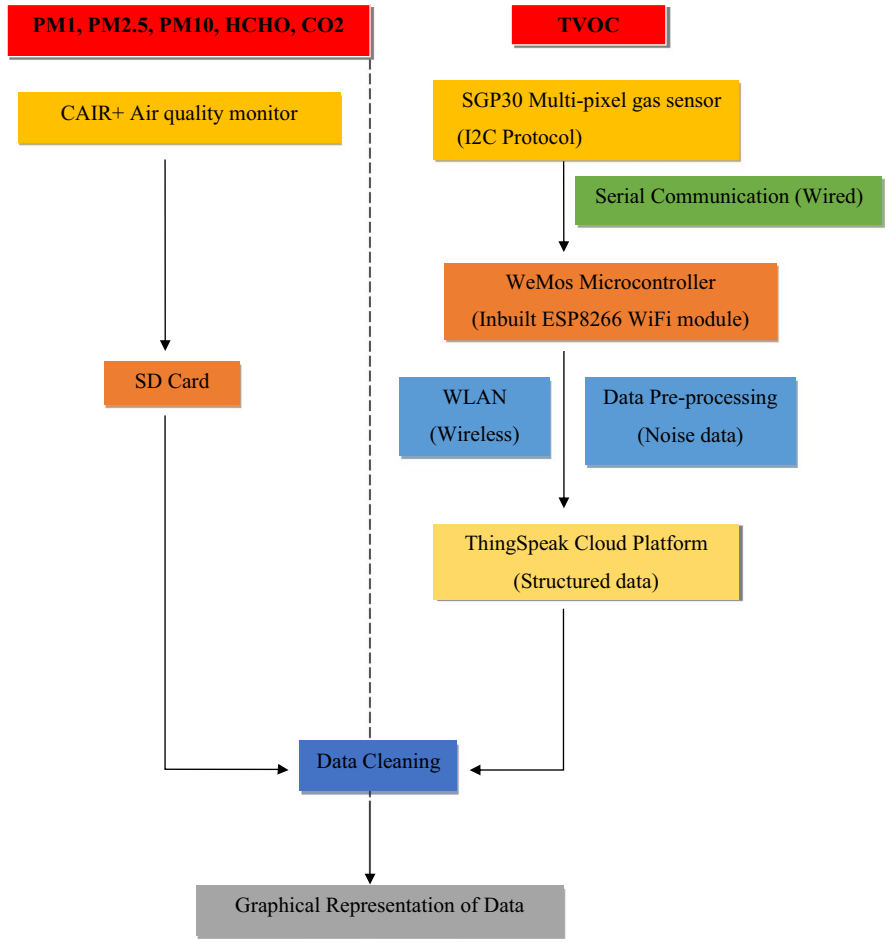


Fig. 4 Block diagram on the detailed instrument setup

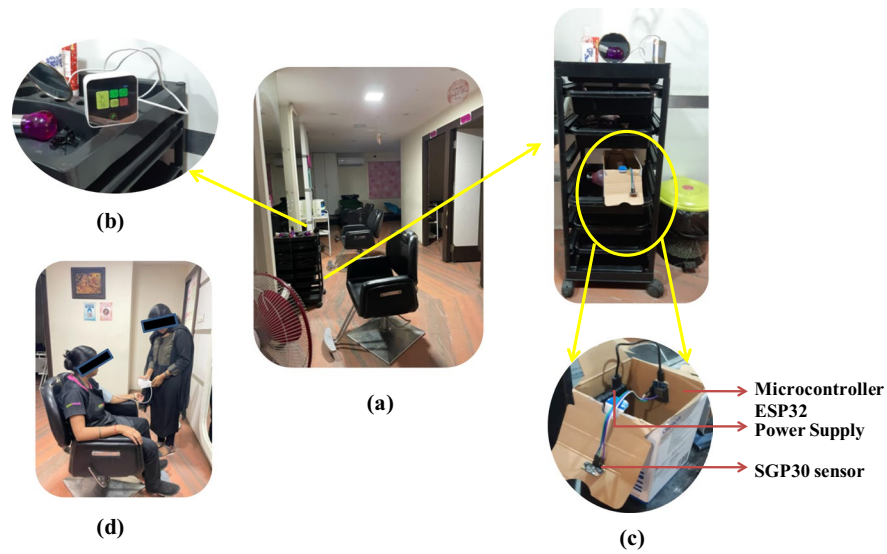


Fig. 5 Placement of sensors in the hair salon and measurement of health parameters: (**a**) hair salon with sensors; (**b**) CAIR + Air quality monitor; (**c**) SGP30 air quality sensor; (**d**) measurement of blood pressure using OMRON Blood pressure monitor

3 Results

Concentrations of PM1, PM2.5, PM10, HCHO, CO2, and TVOC were measured in 4 hair and beauty salons. The meteorological and health parameters were also recorded simultaneously. The basic characteristics of the 4 hair beauty salons are listed in Table 1.

The following Tables 2 and 3 represent the 15 min average concentrations of each pollutant measured during weekdays and weekends respectively.

The correlations of compounds with different pollutant concentrations are compared. Spearman's correlation is carried out. Figures 6 and 7 represent the correlation of pollutant concentrations on weekdays

Table 1 Characteristics of sampling locations

Salon No	Ventilation[a]	Area (m^2)	Working hours (h)	No. of cosmetologists	Type of ongoing treatments	No. of customers[b]	
1	F + AC	176	14	10	Haircut, hair coloring, facial, hair massage	W.D	32
						W.E	43
2	F + DO	140	14	3	Haircut, hair straightening, facial, waxing, threading	W.D	16
						W.E	14
3	F + DO	400	5	1	Haircut, facial, waxing, threading	W.D	5
						W.E	5
4	AC	1000	10	5	Haircut, hair straightening, hair spa, facial, waxing, threading, pedicure, manicure	W.D	9
						W.E	8

[a] *F + AC*, fan + air conditioned; *F + DO*, fan + door opened; *AC*, air conditioned

[b] *W.D*, weekday; *W.E*, weekend

Table 2 Descriptive statistics of weekday concentrations of air pollutants

	PM1 (µg/m3)	PM2.5 (µg/m3)	PM10 (µg/m3)	CO2 (ppm)	HCHO (µg/m3)	TVOC (ppb)
Count	67.00	67.00	67.00	67.00	67.00	67.00
Mean	29.41	36.44	43.52	1070.14	0.02	108.95
std	18.15	23.91	27.73	309.29	0.01	117.08
Min	1.69	1.67	1.86	809.73	0.01	1.68
25%	23.68	24.54	26.83	902.31	0.01	21.06
50%	30.12	38.30	45.68	1002.66	0.01	78.90
75%	33.14	45.46	56.70	1076.56	0.02	151.32
Max	127.77	154.38	168.76	2259.91	0.03	567.70

Table 3 Descriptive statistics of weekend concentrations of air pollutants

	PM1 (µg/m3)	PM2.5 (µg/m3)	PM10 (µg/m3)	CO2 (ppm)	HCHO (µg/m3)	TVOC (ppb)
Count	71	71	71	71	71	71
Mean	34.61293	46.40355	56.63016	1046.231	0.014514	141.4878
std	16.1671	21.06459	24.77121	205.4021	0.008362	157.5013
Min	12.06944	13.79167	16.23611	808.1278	0.009	1.05
25%	23.14167	28.48333	34.51667	934.2194	0.010006	33.89167
50%	34.80556	48.52222	60.07222	981.8278	0.011	92.52
75%	37.08944	51.93056	65.02222	1071.188	0.014811	178.0167
Max	122.0778	149.5167	167.0833	1767.72	0.049472	767.6

and weekends. Particulate matter such as PM1, PM2.5, and PM10 is said to have higher correlations.

The relationship between the temperature, relative humidity, and the measured concentrations of the pollutants is determined using simple linear regression. Table 4 shows the regression model between temperature, relative humidity, and the concentration of other pollutants measured. A significant relationship between temperature and particulate matters such as PM1, PM2.5, and PM10 was observed.

The weekend and weekday data are compared to find the difference between the concentrations of measured pollutants. The following figures represent the weekday and weekend comparison of the concentration of the measured pollutants for salons 1, 2, 3, and 4 respectively.

The weekday concentrations of the particulate matter, CO2, and HCHO are comparatively high compared to the weekend data in salon 1 (Fig. 8). This primarily depends on the type of ongoing treatments. Figure 9 shows that the measured concentration of all the pollutants is comparatively high on weekends than weekdays.

A trend similar to salon 2 is observed in salon 3 (Fig. 10). The weekend concentration of the measured

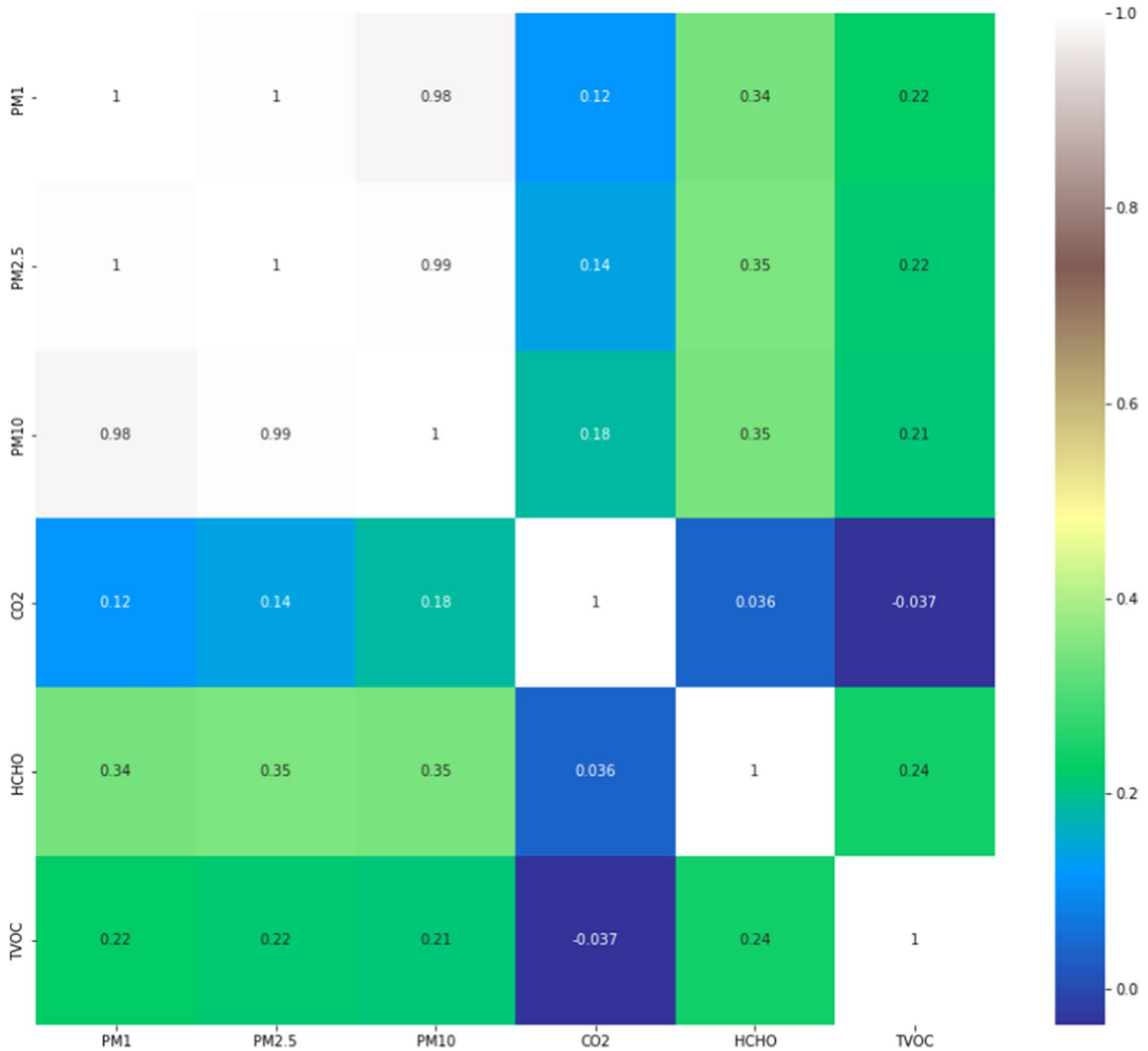


Fig. 6 Spearman's correlation of pollutant concentrations measured during weekdays

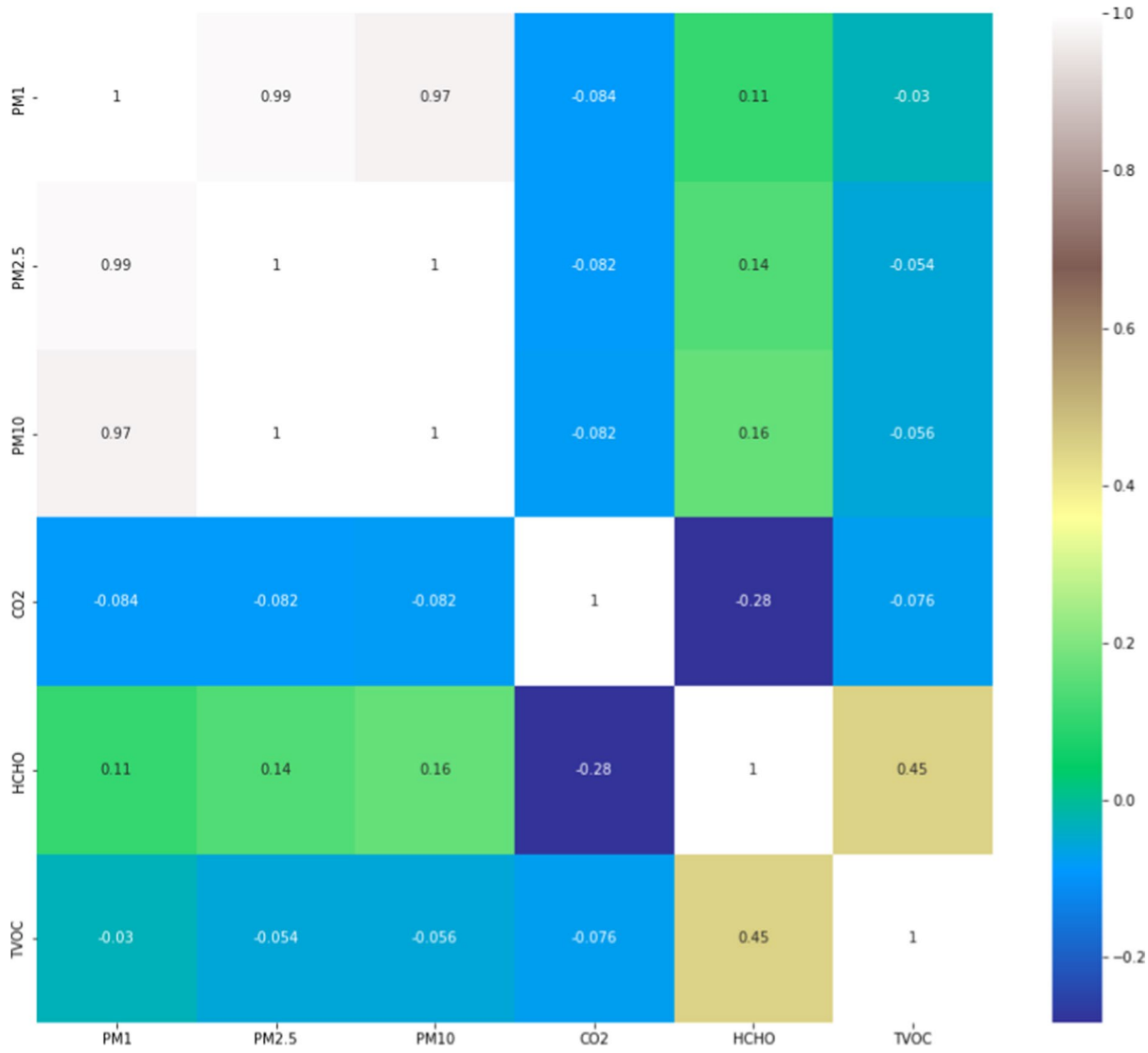


Fig. 7 Spearman's correlation of pollutant concentrations measured during weekends

pollutants is considerably high when compared with the weekday concentration. This is primarily due to the characteristics of the ongoing hair treatment techniques. In salon 4, the weekday concentrations of the particulate matter, HCHO, and TVOC are higher on weekdays than on weekends (Fig. 11). The concentration of the pollutants depends on hair treatment techniques, thus abiding with the conclusions derived from previous observations.

Figures 12 and 13 show the observation made during the treatment process. A rapid increase in the TVOC levels was observed during a certain time and then it decreases. At that certain time, activities such as hair gel application, facials, and head massage took place. An 81.5% increase in the TVOC levels was noted during shaving and head massage (Fig. 12). Also, Fig. 13 shows a 99.8% increase in the TVOC levels while applying hair gels. Thus, TVOC levels are observed to be 80–90% higher during facials and hair gel application.

The systolic and diastolic blood pressure measured before and after work is compared to find the difference in the systolic and diastolic values and determine their changes. The pulse rate measured is

Table 4 Regression table between meteorological parameters such as temperature, relative humidity, and concentration of the measured pollutants

Pollutants	Meteorological parameters	R^2 value
PM1	Temperature	0.514
	Relative humidity	0.236
PM2.5	Temperature	0.535
	Relative humidity	0.245
PM10	Temperature	0.509
	Relative humidity	0.211
CO2	Temperature	0.066
	Relative humidity	0.349
HCHO	Temperature	0.046
	Relative humidity	0.239
TVOC	Temperature	0.051
	Relative humidity	0.063

also compared in the same way. Figures 14 and 15 represent the comparison of systolic and diastolic blood pressure and pulse rate, respectively.

The minimum and maximum systolic and diastolic blood pressure range for the age group of 25 to 29 years varies from 109/76 to 133/84. But the blood pressure value of the hairdresser (worker ID: 4) belonging to the respective age group is observed to be above the maximum range (Fig. 14). Also, the minimum and maximum systolic and diastolic blood pressure range for the age group of 50 to 54 years varies from 116/81 to 142/89. But the blood pressure value observed for the hairdressers (worker ID: 5, 12) belonging to the respective age group exceeds the maximum range. Similarly, the minimum and maximum systolic and diastolic blood pressure range for the age group of 30 to 34 years is between 110/77 and 134/85. It is found that hairdressers (worker ID: 7, 16) falling in that respective age group have blood pressure values exceeding the maximum range.

4 Discussion

The air pollutants namely PM1, PM2.5, PM10, TVOC, CO2, and formaldehyde and meteorological parameters such as temperature and relative humidity were measured in four hair salons. The influence

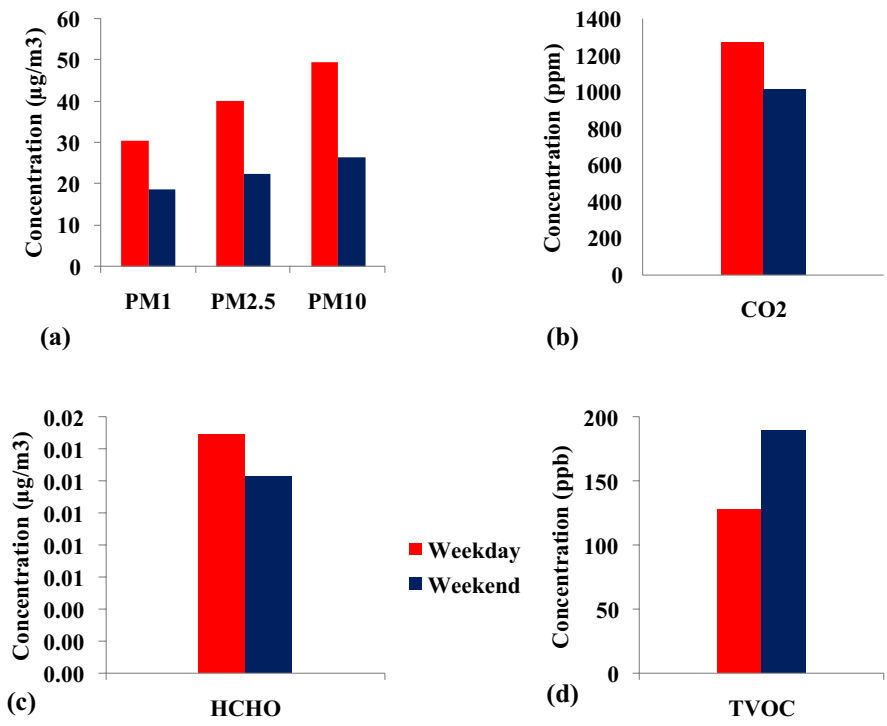


Fig. 8 Weekday and weekend comparison of measured air pollutant concentrations for salon 1: (a) particulate matter, (b) CO2, (c) formaldehyde, (d) TVOC

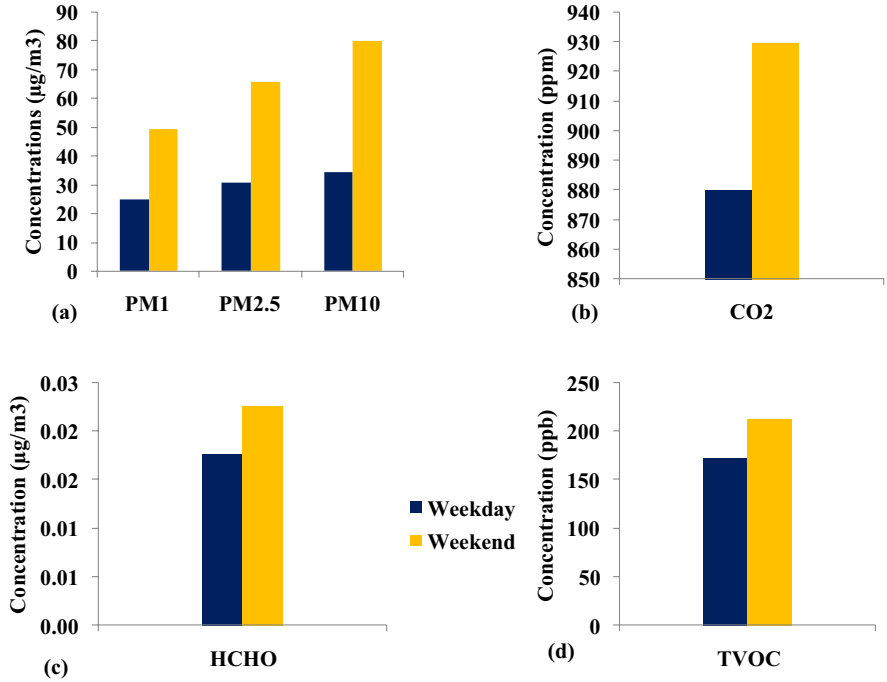


Fig. 9 Weekday and weekend comparison of measured air pollutant concentrations for salon 2: (a) particulate matter, (b) CO2, (c) formaldehyde, (d) TVOC

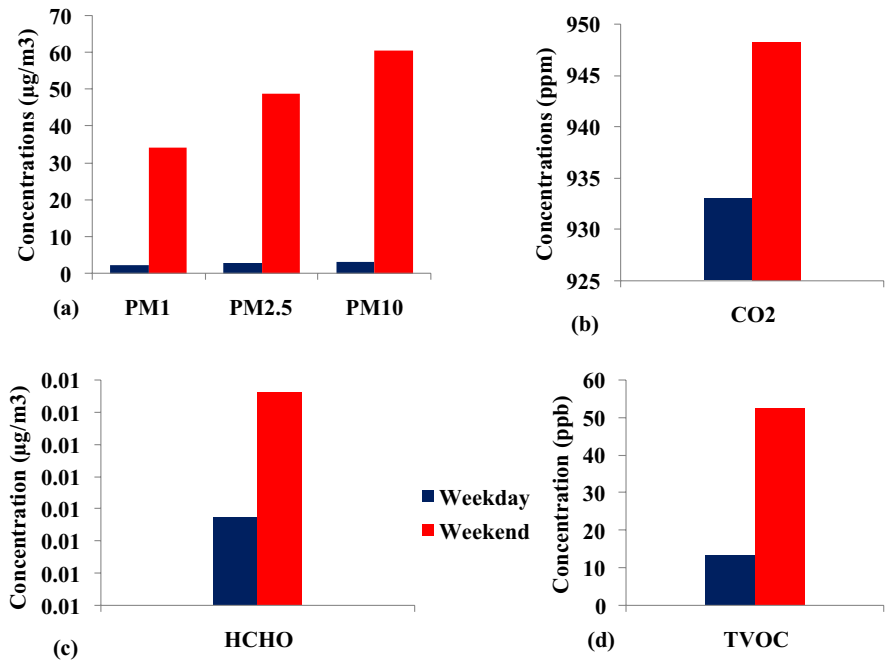
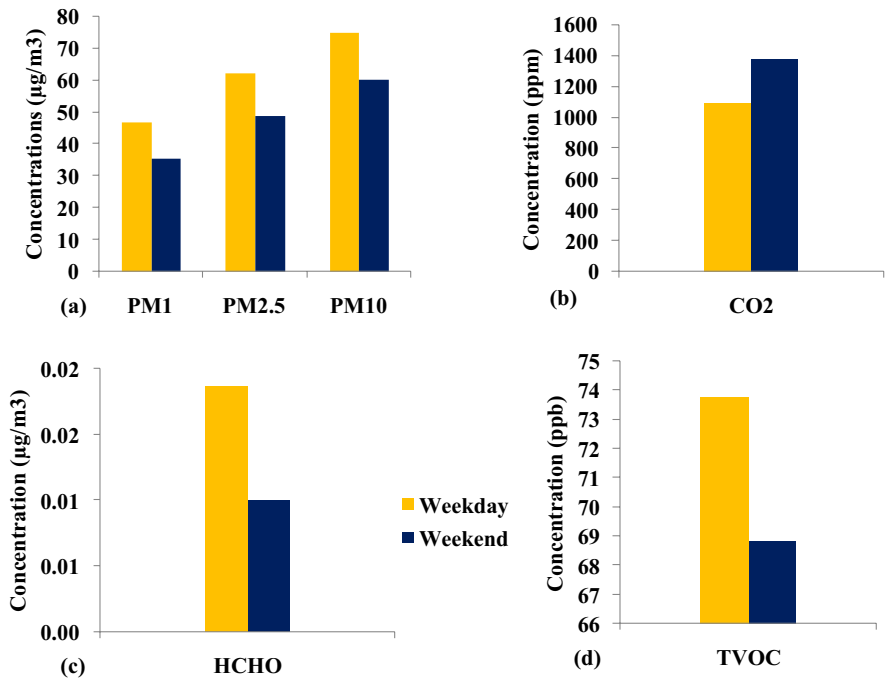


Fig. 10 Weekday and weekend comparison of measured air pollutant concentrations for salon 3: (a) particulate matter, (b) CO2, (c) formaldehyde, (d) TVOC

of meteorological parameters such as temperature and humidity has significant impacts on indoor air quality and it is found that the air is fresher when the temperature and humidity are low (Berglund & Cain, 1989). The same study also concludes that the effect of temperature was stronger and linear than the relative humidity. Table 4 shows that there is a significant relationship between temperature and particulate matters such as PM1, PM2.5, and PM10. Thus, the concentration of the particulate matter



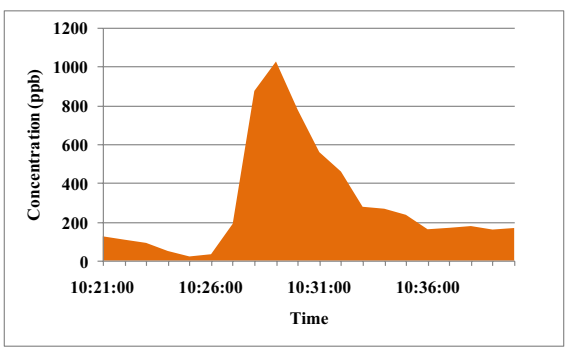


Fig. 12 Concentration of TVOC during shaving and head massage

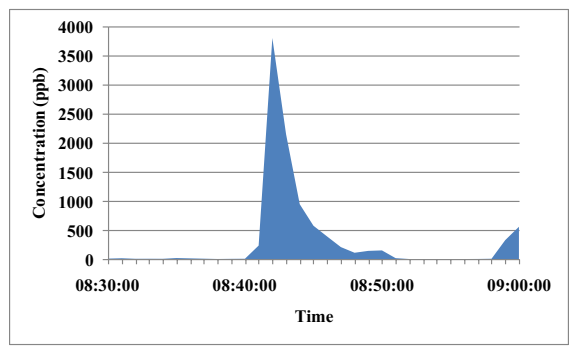


Fig. 13 Concentration of TVOC during haircut and head massage

may increase with the temperature resulting in poor indoor air quality. When the relationship between the relative humidity and concentrations of the measured pollutants was determined, no such significant relationship was found.

The data was collected both during weekdays and weekends to observe the influence of external factors such as number of customers on indoor air quality. The maximum 15 min average value of PM1, PM2.5, PM10, CO2, HCHO, and TVOC are 122, 150, 167, 1768, 0.05, and 768 respectively during weekdays and the weekend maximum concentrations are 128, 154, 169, 2260, 0.03, and 568 respectively. In the case of salon 1, more haircuts were carried out during the weekdays. Thus, the concentration of particulate matter is high during weekdays. PM2.5 values observed exceeded the standard value of 35 µg/m^3 most of the time and a maximum value of 59.75 µg/m^3 was noted. In the case of TVOC, the weekend concentration is high and a maximum value of 1344 ppb was noted down, which exceeds the standard and permissible limit of 500 and 300 ppb respectively. This is because hair treatments such as hair coloring and facials were

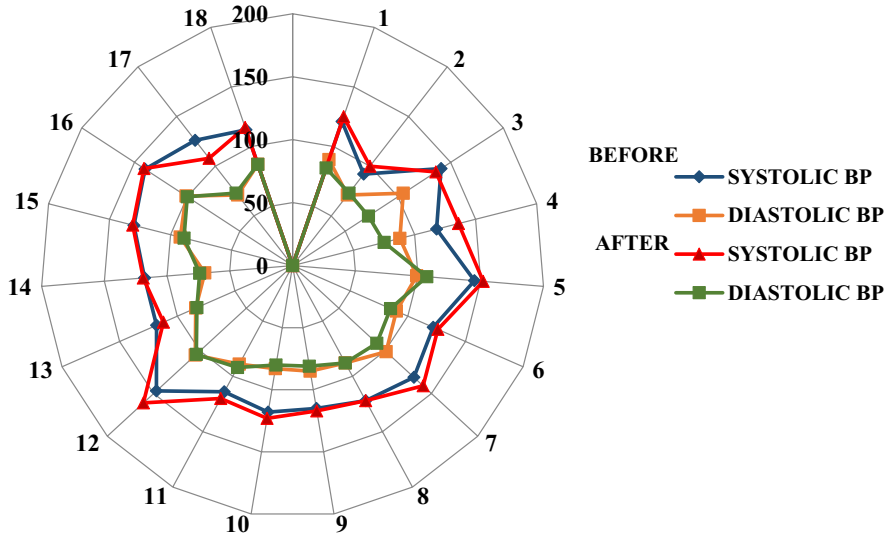


Fig. 14 Systolic and diastolic blood pressure before and after work

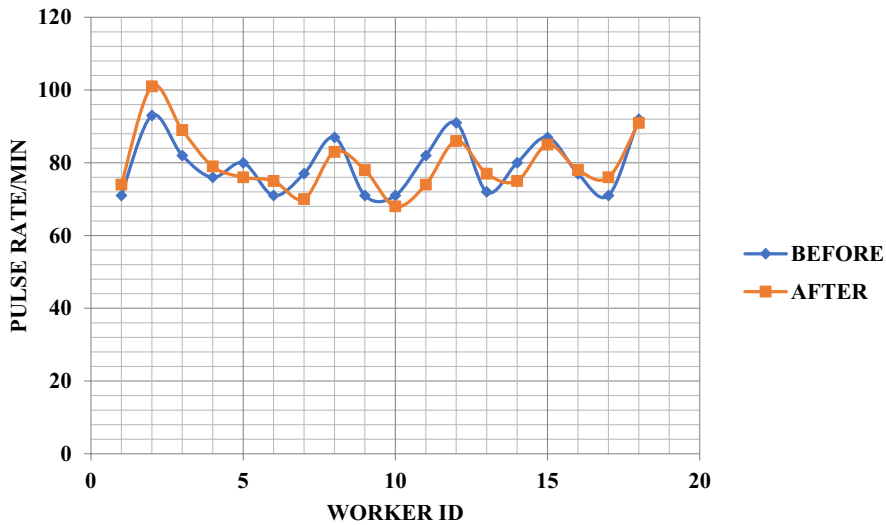


Fig. 15 Pulse rate/min before and after work

predominant during the weekend compared to weekdays. A similar observation was reported in salons 2 and 3 where the hair techniques involving many chemical products, such as hair gels, were used on weekends resulting in high pollutant concentration. The highest TVOC concentration of 5248.25 ppb was observed at salon 2. This clearly shows that the type and nature of the hair techniques affect the pollutant concentration irrespective of the number of customers visited and the surface area. A similar observation was reported in a previous study where the indoor air quality was assessed in 12 hair salons and no such influences were observed (Gennaro et al., 2014).

The TVOC level is said to increase during shaving and head massage treatments. The TVOC level also increases during hair gel application. When no activities occur in the salon, the TVOC levels are observed to be less and within the standard limits. During operations such as shaving, head massage, and facials, the TVOC level tends to increase. A significant percentage (81.5 and 99.8) increase was reported during such processes. Thus, an overall increase of 80–90% occurs rapidly. This rapid increase in the TVOC levels exceeds the standard value twofold to threefold. Correspondingly, previous studies carried out to assess the IAQ in hair

salons also reported an average TVOC value greater than the standard value of 300 µg/m3 (Gennaro et al., 2014; Kezic et al., 2022; Ma et al., 2010; Mendes et al., 2011; Moda & King, 2019). When the associated hairdressers inhale or come in contact with the increased concentration of TVOCs, they might face severe health issues. These health impacts include allergies and respiratory effects such as asthma or chronic obstructive pulmonary disease (Lerner et al., 2012). Also, elevated TVOC levels can cause headaches and irritation. Some TVOCs are said to be carcinogenic and irritants (Meyer, 2018). Similar observations were also reported in the trend of particulate matter. When activities such as trimming, cutting, and shaving are carried out, particulate matter concentration increased rapidly, reporting values about 150 ~ 170 µg/m^3. Studies have also found out that the hairdressers could be exposed to high levels of particulate matter during their 8-h shifts (Shao et al., 2021).

The systolic and diastolic blood pressure and the pulse rate are comparatively higher after the hair treatment than at rest. Blood pressure exceeding the permissible capacity is observed in many hairdressers. Studies (Capriotti et al., 2000) show that high standard and hypertensive blood pressures are potential causes of cardiovascular disease risks in the occupational setup. When some activities like haircuts take place, the particulate matter concentration is increased. This short-term increase in the concentration of particulate matter (PM2.5) increases the risk of strokes, heart failure, and myocardial infarctions (Brook & Rajagopalan, 2009). Also, studies (Brook & Rajagopalan, 2009) have shown that the most likely contributing factor to all these ill health conditions is an elevation in arterial blood pressure. Continuous exposure to the particulate matter might cause elevated blood pressure observed in the hairdressers. Long-term exposure might also result in chronic hypertension, leading to successive ill health conditions.

5 Conclusion

Industries, transportation, and other significant activities cause the majority of air pollution. These indoor air quality and its effects are frequently overlooked. However, they might cause considerable health effects in the long run. Therefore, the impact of IoT and data analytics provides insight and a competitive edge to assess the IAQ of hair salons. According to the findings of this study, significant relationships were found between the concentration of measured pollutants (PM1, PM2.5, and PM10). The maximum 15 min average concentration values of PM1, PM2.5, and PM10 were 128, 154, and 169 µg/m3 respectively. A significant relationship was also found between temperature and particulate matter. On the other hand, TVOC levels are observed to be around 80–90% higher during facials and hair gel application and a maximum value of 5248.25 ppb was observed at salon 2. One-third of the hairdressers displayed high blood pressure and a maximum value of 161/104 was measured which can lead to stage 2 hypertension. Thus, continuous exposure to particulate matter and other pollutants for the entire working hours might cause severe health issues in the long run. The best approach to improve indoor air quality and to protect the health of hairdressers is to adopt suitable ventilation and promote the usage of certified hair products. This research highlights the significance of indoor quality in hair salons and their associated health effects. Few studies underline the indoor air quality in hair salons and pave the way for future researchers to focus more on occupational indoor air quality as these have substantial environmental and health effects.

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Declarations

Ethics Approval Not applicable.

Consent to Participate Not applicable.

Consent for Publication Not applicable.

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