ORIGINAL PAPER

The concentration of volatile organic compounds (VOCs) and related factors in the air in barbershops in Sanandaj in 2016

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ABSTRACT

The aim of this study was to determine the density of benzene and toluene in barbershops of Sanandaj and also to determine effective factors for this pollution. A descriptive, analytical study was conducted to measure the volatile organic compound density and determine the effective factors. In this study, five hair salons and five barber shops were randomly selected from Sanandaj city. The volatile organic compound density was measured by using Phocheck device, Tiger model, made in England, equipped with a PID lamp (Photoionisation detector lamp). Also, the other effective variables that affect the density of these compounds including temperature, humidity, type of service provided, and the type of conditioner were measured in summer and autumn. Statistical analysis using t-test and ANOVA was performed using SPSS software version 18**.** In the makeup salons, toluene had the highest density (with an average concentration of 0.821200 ppm), and ethylbenzene had the least density (with an average concentration of 0.015532 ppm). Between the density of volatile organic compounds, it was one of effective factors of them. Based on the impact of natural ventilation, it is recommended to reduce contaminants in beauty salons. Environmental health inspectors should consider this variable in their surveys.

Keywords: Volatile organic compounds, Hairdressers, Sanandaj, Air pollution

Introduction

Air pollution in cities and workplaces as one of the consequences of urban development, the growth of technology in the industry, and the discovery and application of various types of chemicals with different properties have caused a wide range of acute and chronic health effects and economic losses.[1,2] In today's societies, lifestyles are such that most people tend to spend more time in an indoor environment, such as homes and workplaces. This shows the importance of the air quality of the indoor environments. In the recent years, attempts to save on energy consumption and the resultant reduction in the inlet and outflow of indoor air, as well as increased use of artificial materials in buildings, have led to complaints of poor indoor air quality due to the accumulation of contaminants.[3,4] Beauty salons are a kind of closed-environment spaces that contain a wide variety of chemicals, including cosmetics (all types of shampoos, lotions, hair dye, hair glue, spray, varnish, gel, etc.), cleaners and detergents, disinfectants, and so on. Each component of the cosmetic products and detergents includes several types of volatile organic compounds, acrylates, phthalates, and aldehyde forms.[4] One of the most important threats detected in such environments is volatile organic compounds (VOCs) whose concentration levels are higher than those in outdoor environments.[5,6] VOCs are liquid or solid materials that contain organic carbon and evaporate rapidly. These compounds have the highest frequency and diversity of diffusion after suspended particles.[7] VOCs are known as compounds that exist everywhere and can be considered as the most important pollutants for assessing the quality of indoor and outdoor air, as presented in various studies. These compounds include a wide variety of air pollutants, and among them, benzene, toluene,

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ethylbenzene, and zeolin are found in many indoor environments.[8,9] Exposure to VOCs, depending on the composition and concentration, can produce short-term and long-term effects on health and well-being. The health effects of VOCs in indoor environments can be in the form of sensory effects at low and medium concentrations to toxic effects at high concentrations.[6] Also, respiratory complications, such as asthma or chronic obstructive pulmonary disease, are associated with exposure to VOCs.[10] According to the instructions given by Molhave, total VOC levels should not exceed 200 µg per cubic meter for human well-being.[1] Considering the importance and hazard of the presence of organic matter in indoor environments, including beauty salons, the purpose of this study was to determine the VOCs in Sanandaj's beauty shops and the factors that affect the concentration of these compounds.

Materials and Methods

This descriptive, analytical study was conducted in women's and men's barbershops of Sanandaj in 2017. Sampling was done after coordination with the health department and environment and occupational health departments of Kurdistan University of Medical Sciences and obtaining a letter of reference from the collaboration of hairdressers. With the necessary coordination with the Sanandaj Barbers Union, five women's barbershops and five men's barbershops were selected from among the busy hairdressing salons. The samples were collected between 10 a.m. to 12 p.m. and also from 16 p.m. to 19 p.m., entirely randomly during the summer and autumn seasons, with two repetitions in each season. A total of 120 samples were collected. In order to prevent outdoor contaminated air from entering indoors, beauty salons out of the city center, away from industries and factories, were considered. During the measuring process and even later, smoking was forbidden. By inspecting the beauty salons, firstly, information about the ventilation features used (door and window position, ceiling fan, desk flashing, etc.), the type of products used, and the services provided (pedicure, manicure, waxing, coloring of hair, etc.) were collected by using a questionnaire. On the same day, the moisture content and temperature were also measured using psychrometer and thermometer, respectively. Then, to measure the concentration of VOCs in the indoor air in beauty salons, a PhoCheck Tiger portable device made in England, equipped with a PID bulb, model 10.6 eV with a minimum sensitivity of 0.001 ppm (1ppb) was used. After obtaining the above information, the device was turned on and measurement of the composition of indoor air with respect to each organic compound (benzene, toluene, xylene, ethylbenzene, ethyl acetate, and acetone) was done for 10 minutes (according to the instrument manual) at a distance of 30 cm from the wall, 1.5 meters from the floor, and at three points in the hall (first point, near the completion of work; second point, near the ventilation; third point, the middle of the hall). The average value was recorded each time.

Table 1. The frequency of measuring the effective parameters

Row	Measured parameters	Amount
A	Number Men's hairdresser	5
B	Number Women's beauty salons	5
C	Number of samplings in the barbershop	20
D	Number of samplings in the beauty salons	20
E	Number Season of sampling	2
F	Volume of beauty salons and barbers (meter)	30-65
G	Number Time of working (hours)	7-15
H	Number of persons work at that place	1-3
I	Number of persons served	6-30
J	Time to serve each person (min)	10-45
K	Number Use of personal protective equipment	0

SPSS software version 18 was used to analyze the data, and t-test and ANOVA were used to examine the relationship between the variables.

Results and Discution

In this study, the temperature varied from 18 to 30 ºC during the different seasons and barbers and beauty salons. Different hair salons used different types of ventilation, including artificial ventilation (fans), natural (door and window), or even both. We observed that the barbershops used more natural ventilation, but beauty salons, because of hijab and hairdressing coverage, used more artificial ventilation.

Seventy percent of the barbershops and beauty salons used artificial ventilation, 7.5% used natural ventilation, and 22.5% used natural and artificial ventilation simultaneously. The moisture levels varied from 21% to 28% in the different hair salons and seasons. When visiting the hair salon, a variety of services, including the use of sprays, hair dye and nail polish, solids (gels and pancakes, etc.), and face shaving, were taken into consideration. Of the various services, 12.5% were related to using solids, 30% to spray application, 25% to facial makeup, 12.5% to color (hair dye), and 20% to hair regrowth.

Volatile Organic Compounds

In this study, six components of VOCs such as benzene, ethylbenzene, toluene, xylene, ethyl acetate, and acetone were measured. Toluene was present in the highest concentration with a maximum value of 0.660 ppm and a minimum of 0.350 ppm. The lowest concentration was seen for ethylbenzene with a maximum value of 0.200 ppm and a minimum of 0.007 ppm. The maximum and minimum concentrations of pollutants are listed in Table 2. The concentration of toluene, xylene, and acetone did not have any significant relationship with the type of hairdressing salon.

Table 2. The range of concentrations of volatile organic compounds (PPM)

Pollutant	Number of measurements	Minimum concentration	Maximum concentration	Average	Standard deviation	Standard amount (NIOSH)
Benzene	40	0.0300	0.1600	0.076325	0.0327464	50
Toluene	40	0.3500	1.6600	0.821200	0.3387803	200
Ethyl benzene	40	0.0070	0.0320	0.015532	0.0066863	100
Xylene	40	0.2100	1.0500	0.515975	0.2159866	100
Ethyl Acetate	40	0.1300	0.7000	0.337875	0.1441381	400
Acetone	40	0.2880	1.5600	0.764675	0.3199648	1000

The results of this study showed that there was a significant relationship between the sampling period and the concentration of pollutants, with a higher concentration of organic compounds in summer than winter ($P < 0.05$). Of course, the results of other studies were different, with the concentration of pollutants being higher in the cooler season than in the warm season. A higher amount of referrals to the hairdressing salon in the summer, as well as the use of synthetic ventilation system, have been used to explain this discrepancy in results (Table 3). Of course, the results of other studies were different, with the concentration of pollutants being higher in the cooler season than in the warm season.

There was a significant relationship ($P < 0.05$) between the type of hairdressing salon (for males or females) and the concentration of benzene, ethylbenzene, and ethyl acetate; the concentration of these compounds in the hairdressing salons for females was more than that in the salons for males. The use of hair dyes and taftes in female beauty salons can be a justification for this (Table 4).

Table 3. Effect of season on the concentration of volatile organic compounds

Variables	season	Size of sample	Average (ppm)	P-value
benzene	summer	20	0.092850	0.001
	autumn	20	0.059800	
Toluene	summer	20	1.005050	0.000
	autumn	20	0.637350	
Xylene	summer	20	0.631300	0.000
	autumn	20	0.400650	
Ethyl benzene	summer	20	0.018865	0.001
	autumn	20	0.012200	
Acetone	summer	20	0.935850	0.000
	autumn	20	0.593500	
ethyl acetate	summer	20	0.412500	0.001
	autumn	20	0.263250	

In this study, a significant relationship was found between the type of ventilation and the concentration of VOCs ($P < 0.05$). Natural ventilation resulted in the removal of organic pollutants, and the reduction in their concentrations was more significant in comparison with that due to synthetic ventilation. The natural ventilation was done using windows (Table 5).

Table 4. The effect of the type of hair salon on the concentration of volatile organic compounds

variables	Type of hairdresser	Size of sample	Average (ppm)	P-value
benzene	Female	20	0.087650	0.027
	Male	20	0.065000	
Toluene	Female	20	0.909250	0.101
	Male	20	0.733150	
Xylene	Female	20	0.572000	0.101
	Male	20	0.459950	
Ethyl benzene	Female	20	0.017650	0.044
	Male	20	0.013415	
Acetone	Female	20	0.851450	0.086
	Male	20	0.677900	
Ethyl acetate	Female	20	0.382800	0.047
	Male	20	0.292950	

Other studies have also documented the effect of doors and windows in the beauty salon on the concentration of VOCs.[12-15] In a study aimed at determining the extent of exposure to chemical pollutants in the makeup salons, the concentration of VOCs was lower than the permitted exposure limit, which is consistent with the results of this study.[4]

Table 5. Effect of ventilation type on the concentration of volatile organic compounds

Variables	Ventilation type	Size of sample	Average (ppm)	P-value
Benzene	Synthetic	28	0.086214	0.009
	Natural	3	0.061333	
	Synthetic- natural	9	0.050556	
Toluene	Synthetic	28	0.919143	0.015
	Natural	3	0.660000	
	Synthetic- natural	9	0.570222	
Xylene	Synthetic	28	0.578321	0.014
	Natural	3	0.421000	
	Synthetic- natural	9	0.353667	
Ethyl benzene	Synthetic	28	0.017429	0.019
	Natural	3	0.011667	
	Synthetic- natural	9	0.010922	
Acetone	Synthetic	28	0.858821	0.012
	Natural	3	0.630000	
	Synthetic- natural	9	0.516667	
Ethyl acetate	Synthetic	28	0.382000	0.008
	Natural	3	0.271333	
	Synthetic- natural	9	0.222778	

Also, the findings of the study show the impact of the type of services on the concentration of organic compounds. There was a significant relationship between the type of services provided and the concentration of the VOCs ($P < 0.05$). Use of spray, hair color, solids such as gel and pancake, facial makeup, and haircut resulted in the lowest VOC concentrations (Table 6).

Table 6. Impact of the type of service provided during measurement on the volatile organic compound concentration

Variables	Services	Size	Average (ppm)	P-value
Benzene	The use of solids (gels, etc.)	5	0.063200	0.000
	Spray (taffeta and glue ...)	12	0.108417	
	Face Makeup	10	0.059800	
	Color (hair, nails, mustache and ...)	5	0.083200	
	hair cut	8	0.052750	
Toluene	The use of solids (gels, etc.)	5	0.682000	0.000
	Spray (taffeta and glue ...)	12	1.166417	
	Face Makeup	10	0.634000	
	Color (hair, nails, mustache and ...)	5	0.861000	
	hair cut	8	0.599500	
Xylene	The use of solids (gels, etc.)	5	0.426600	0.000
	Spray (taffeta and glue ...)	12	0.736917	
	Face Makeup	10	0.393000	
	Color (hair, nails, mustache and ...)	5	0.546000	
	hair cut	8	0.375375	
Ethyl benzene	The use of solids (gels, etc.)	5	0.013800	0.000
	Spray (taffeta and glue ...)	12	0.021917	
	Face Makeup	10	0.011600	0.000
	Color (hair, nails, mustache and ...)	5	0.016400	
	hair cut	8	0.011413	
Acetone	The use of solids (gels, etc.)	5	0.617800	0.000
	Spray (taffeta and glue ...)	12	1.088750	
	Face Makeup	10	0.590400	
	Color (hair, nails, mustache and ...)	5	0.818000	
	hair cut	8	0.554875	
ethyl acetate	The use of solids (gels, etc.)	5	0.284200	0.000
	Spray (taffeta and glue ...)	12	0.478500	
	Face Makeup	10	0.259700	
	Color (hair, nails, mustache and ...)	5	0.362200	
	hair cut	8	0.243000	

Use of spray, hair color, solids such as gel and pancake, facial makeup, and haircut resulted in the lowest VOC concentrations. The findings from Alexandra's study in Tasagonia also showed that the type of services provided influenced the concentration of the organic compounds in the air.[4]

The concentration of all the VOCs measured in this study was directly related to the temperature ($P < 0.05$); increased temperature caused an increase in the concentration of all the components of the VOCs (Table 7).

Table 7. The effect of temperature during measurement on volatile organic compound concentration

Variables	Temperature (ºC)	Size	Average (ppm)	P-value
Benzene	18-22	18	0.058	0.000
	23-27	13	0.07	
	28-32	9	0.117	
Toluene	18-22	18	0.618	0.000
	23-27	13	0.8	
	28-32	9	1.26	
Xylene	18-22	18	0.389	0.000
	23-27	13	0.494	
	28-32	9	0.799	
Ethyl benzene	18-22	18	0.012	0.000
	23-27	13	0.015	
	28-32	9	0.024	
Acetone	18-22	18	0.580	0.000
	23-27	13	0.735	
	28-32	9	1.181	
Ethyl acetate	18-22	18	0.257	0.000
	23-27	13	0.324	
	28-32	9	0.520	

The results of this study showed that Humidity was directly related to the concentration of total VOCs measured in this study (Table 8), with the increase in moisture content increasing the concentration of all components of VOCs ($P < 0.05$). The relationship between humidity and ventilation and the concentration of organic compounds in the air has been confirmed in the Tasagonia study.[4]

A higher amount of referrals to the hairdressing salon in the summer, as well as the use of synthetic ventilation system, have been used to explain this discrepancy in results. The area of the hairdressing salon is also an important parameter which determines the concentration of the pollutants because the larger the area, the lower the concentration of VOCs. Of course, the number of employees in each hairdressing salon can minimize the impact of the area. In all the hairdressing salons, smoking was forbidden. So the effect of smoking on the concentration of VOCs was not taken into consideration, but in the study by Sarygianis et al., smoking caused an increase in the concentration of xylene.[13]

Table 8. Effect of moisture during measurement on the concentration of volatile organic compounds

Variables	Moisture (%)	Size	Average (ppm)	P-value
Benzene	21-24	23	0.0647	0.000
	25-28	17	0.0920	
Toluene	21-24	23	0.6997	0.000
	25-28	17	0.9854	
xylene	21-24	23	0.4372	0.000
	25-28	17	0.6225	
Ethyl benzene	21-24	23	0.0130	0.000
	25-28	17	0.0189	
Acetone	21-24	23	0.6513	0.000
	25-28	17	0.9180	
Ethyl acetate	21-24	23	0.2869	0.000
	25-28	17	0.4068	

Conclusion

Based on the impact of natural ventilation, it is recommended to reduce contaminants in beauty salons. Environmental health inspectors should consider this variable in their surveys.

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Conflict of interests

The authors have no conflict of interest to declare with regard to this study.

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