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Indoor and Outdoor Concentrations of Air Pollutants in Beauty Shops at kwangju Area

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The work of hairdressers includes washing, coloring, bleaching, permanent waving, conditioning, and cutting hair. Hairdressers are subjected to a number of physical and toxicological hazards. The toxicological hazards are those resulting from exposure to a wide range of chemicals that are usually classified active processes. In this study, twenty beauty shops were selected to assess the exposure to indoor air pollutants such as VOCs and particulate matter (PM_{10}) during one month from September 1 to September 30, 2003. Indoor air quality of beauty shops might be worse by vehicle emissions because the beauty shops were generally located near roadways. Personal exposures to VOCs and PM_{10} were related to indoor concentrations of beauty shops. According to the questionnaire, hairdressers complained of sore throat, eye irritation, and nervousness as physical symptoms. The measured mean concentrations of respiratory particulates were 30.5ng/㎥ in indoor, 30.5ng/㎥in outdoor and 44.0ng/㎥ on personal levels. The personal concentration was found higher than indoor and outdoor concentrations. The heavy metals mean concentrations were shown as indoor (Na>Zn>Cr), outdoor (Cr>Zn>Pb), and personal (Na>Cr>Zn) levels. Conclusively, customers as well as workers in the beauty shops might be highly exposed to air pollutants from indoor and outdoor sources. Therefore, proper management should be taken to improve the indoor air quality in beauty shops.

Key Words : Hairdressers, VOCs, PM_{10}, beauty shop, Heavy metal

1. Introduction

These days, the exposure ratio to harmful chemicals is very high and the affections from interior materials are higher than those from exterior ones because people spend much time inside buildings[1]. The reason why indoor air quality has to be managed more importantly and carefully because people spend time more than 80% of 24 hours almost every day inside regions (residences, offices, interior work places, public buildings, underground facilities, markets, restaurants, automobiles, subways, and etc.). Additionally energy conservation buildings lead to the accumulation of pollutants due to low ventilation performance in indoor areas.

This study is to analyze the harmful effects from beauty shop indoor air pollutants on human body. The measurements of human exposure time and intensity to pollutants, medical check-up, biochemical examination, and physical check-up are needed to know how much the pollutants have affected human body.

Alcohol, sulfurized ammonium, hydrogen peroxide, aminophenol, coal tar, lead acetate, methylene chloride, propane, formaldehyde, glycol ether, methylethylketone, toluene, xylene, and oil distillate are frequently used in beauty shops. These could be dangerous to skin and incite mucous membrane, the cornea, and the airway. And these materials also cause blister, flare, dropsy, and even skin cancer[2,3].

Volatile organic compounds (VOCs) and PM_{10} which are usually detected easily in beauty shops cause chest pain and a variety of diseases to hairdressers[4].

The quality of life and desire to be a beauty are more and more increased. But researches on indoor

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air pollution and its affection on human body are very insufficient[4,5].

In this study, air pollution density and individualexposure rate to pollutants were measured in twenty beauty shops and questionnaires were carried out to know what symptoms subjects feel.

The results of this study could be used as basic materials to improve air quality of beauty shops and could be helpful to hairdressers and their customers.

2. Methods

Twenty beauty shops in Kwang-Ju city were selected as objects for measurement. VOCs and PM_{10} were measured from Sep. 1, 2003 to Sep.30, 2003 at each site. Measurements were carried out indoor, outdoor and personal conditions. 3M VOCs analyzer (3M Corporation) and Cyclone (SKC Corporation) were used to measure VOCs and PM_{10}.The questionnaires were conducted.

The measurements were carried out in 20 beauty shops which are located in Kwang-Ju city and 20 subjects' exposure to air pollutants was measured. VOCs and PM_{10} density were measured inside and outside of the beauty shops for 24 hours.

The questionnaires used for this study were composed of age, status, construction year of building, number of staffs, ventilation system, air conditioning methods, beauty shop location, responses to environments of beauty shops and respiratory organ symptoms.

OVM passive sample(3M) was used to detect toluene and xylene which are the main air pollutants in the beauty shops. The facilities were operated for 24 hours.

GC/MS (Gas chromatograph mass analyzer) was used for analyzing with 2㎖ sample which had been treated by CS2. This method is very similar to that of the general charcoal tube sampling method. The condition of GC/MS was 31℃ for 2minutes and then the temperature was increased by 5℃ every minute till 100℃. After a pause of one minute, the temperature was increased by 50℃ every minute till 200℃ and then one minute pause was given. 10 materials which should be analyzed were divided in the condition above.

VOCs density was calculated by measurement time, the amount(㎍) from GC/MS and calculation constant. Desorption efficiency which was used for calculation was the suggested value in 3M OVM badge guide.

PM_{10} dust density was identified by semi-micro balance (Sartorious Co. BP21d), and Cyclone which can identify to 0.01 ㎍ after test sample treatment.

Samples of inside air were captured in the middle zone of beauty shops, and outside samples were picked in outer walls and sampling height was 1.5m. Samples for hair dressers were measured around the breathing zones.

3. Results and Discussion

3.1. Subjective symptoms of participants in beauty shops

When participants of this study opened the beauty shops in themorning, 95% of them ventilated the shops. 85% of them agreed that airpollution couldaffect the human health. 80% of them have perceivedlots of dust, and bad smells of perm agents, dye agents and bleachagents in the beauty shops

All subjects agreed that the inside air quality of the beauty shops is worse than that of outside the beauty shops. This means that the hair dressers recognize the air quality of beauty shop is bad. 70% of the hair dressers complain of sore throat, eye irritation, nervousness and 65% complains of fatigue. These symptoms could be caused by chemical agents. Perm agents, bleach agents, dye materials and hair sprays cause sneezing, cold, and chest pain to them (Table 1).

Table 1. Subjective symptoms of participants in beauty shops

	Yes (Number, %)	No (Number, %)
Headache	8 (40.0)	12 (60.0)
Fatigue	13 (65.0)	7 (35.0)
Chest pain	9 (45.0)	11 (55.0)
Sore throat	14 (70.0)	6 (30.0)
Yawning	12 (60.0)	8 (40.0)
Face febricity	9 (45.0)	11 (55.0)
Eye irritation	14 (70.0)	6 (30.0)
Dizziness	6 (30.0)	14 (70.0)
Tremor of the hands and foots	5 (25.0)	15 (75.0)
Eyelid convulsions	7 (35.0)	13 (65.0)
Nervousness	14 (70.0)	6 (30.0)
Sneezing	9 (45.0)	11 (55.0)
Flu	6 (30.0)	14 (70.0)
Cold	7 (35.0)	13 (65.0)
Sputum	4 (20.0)	16 (80.0)

3.2. Measured VOCs concentrations ($\mu g/m^3$) in beauty shops

Various kinds of VOCs have been detected. Among them, toluene and xylene were detected in every beauty shop. Hence, these were used as materials to compare their relative concentrations and to analyze the relationship with other factors. The beauty shops are usually near a street and windows are usually shut. Indoor pollution is related to nail enamel, base coat and top coat. Other VOCs materials including acetone were very different among the beauty shops and even not detected in some beauty shops. These materials were not used as subjects to compare and analyze. Xylene from paint, lacquer and acetone used to remove enamel on nails. bring about irritative smells and skin irritation. The density of xylene in indoor is higher than that of outdoor and personal exposure(Table 2).

The relationship between toluene and xylene is shown in Table 3. For toluene, the coefficiency of correlation between Indoor and Outdoor was 0.087. The coefficiency between Indoor and Personal was 0.535, and the coefficiency of between outdoor and personal 0.322. This indicated significant relationship in statistics. For xylene, the coefficient of correlation between Indoor and Outdoor is 0.358. And the coefficient between Indoor and Personal is 0.452, which shows that indoor air quality affects personal exposure (Table 3).

3.3. Indoor and outdoor PM10 concentration ($\mu g/m^3$) of beauty shops, and personal exposure

The average PM_{10} and standard deviation of indoor,outdoor,personal exposure were,30.5±25.8$\mu g/m^3$, 31.0±53.6$\mu g/m^3$, 38.6±34.1$\mu g/m^3$ respectively. Personal exposure was higher than that of Indoor and Outdoor (Table4). The high density had been speculated because the location of beauty shop was near streets. However, low density shown above means that the dust of hair is larger than 10μm in diameter.

For PM_{10}, the coefficient of correlation between Indoor and Outdoor is 0.022 and the coefficient between Indoor and Personal exposure is 0.070. But the coefficient between Personal exposure and outdoor is 0.416. It was statistically significant. (Table 5).

Table 6 presents the mean concentration of heavy metals measured indoor. This study measured relatively high concentrations of Na (1849±850 ng/m^3) and Zn (369.649±751.317 ng/m^3).

Kim et al[5] have reported the concentrations of Pb, Ni, Mn, and Cr is their recent study for indoor air quality of beauty shops.

The concentration was higher in order of Pb (1130±4820 ng/m^3), Ni (860±1940 ng/m^3), Mn (470±

Table 2. Measured VOCs concentrations ($\mu g/m^3$) in beauty shops(N=20)

	Indoor concentration (Mean±S.D)	Outdoor concentration (Mean±S.D)	I/O concentration (Mean±S.D)	Personal exposure (Mean±S.D)
n-Octane	N.D.	N.D.		N.D.
Acetone	31.7 ± 65.1	0.4 ± 1.8		42.1 ± 75.2
Ethyl acetate	0.8 ± 3.5	1.5 ± 6.7		1.8 ± 4.3
Benzene	0.2 ± 0.7	0.1 ± 0.2		0.01 ± 0.4
Ammonia	1.3 ± 3.5	0.8 ± 1.7		10.2 ± 9.4
MIBK	0.5 ± 2.4	1.0 ± 3.1		0.8 ± 2.6
Perchloroethylene	5.2 ± 23.0	1.5 ± 6.7	0.96 ± 0.08	4.5 ± 20.1
Toluene	9.8 ± 5.8	10.2 ± 9.4	1.37 ± 3.4	11.2 ± 6.2
Buthyl acetate	3.1 ± 7.7	0.9 ± 4.0		2.2 ± 6.9
Ethyl benzene	0.6 ± 1.8	0.8 ± 2.0		1.7 ± 2.4
Xylene	30.3 ± 20.3	22.1 ± 18.2		25.6 ± 21.2
Styrene	1.1 ± 3.8	0.3 ± 1.5		1.3 ± 3.4
1,2,4 - Trimethylbenzene	N.D.	N.D.		0.3 ± 1.4
1,2 - Dichlorobenzene	N.D.	N.D.		1.9 ± 8.3

* N.D.: Not Detected.
* (a) cannot be computed because the standard deviation is 0.
* MIBK: Mentyl Isobutyl Ketone.

Table 3. Correlation among indoor, outdoor and personal exposure for VOCs

		Indoor	Outdoor	Personal exposure
Toluene	Indoor	1.000		
	Outdoor	0.087	1.000	
	Personal	0.535*	0.322*	1.000
Xylene	Indoor	1.000		
	Outdoor	0.358*	1.000	
	Personal	0.452*	0.123	1.000

* $p < 0.05$

Table 4. Indoor and outdoor PM_{10} concentration ($\mu g/m^3$) of beauty shops, and personal exposure

	Mean ± S.D
Indoor	30.5 ± 25.8
Outdoor	31.0 ± 53.6
Indoor/outdoor (I/O)	0.98 ± 0.11
Personal exposure	38.6 ± 34.1

Table 5. Correlation among indoor, outdoor and personal exposure for PM_{10}

	(1)	(2)	(3)
(1) Indoor	1.000		
(2) Outdoor	0.022	1.000	
(3) Personal exposure	0.070	0.416*	1.000

* $p < 0.05$

3180 ng/m³) and Cr (320±1490 ng/m³). This study measured the concentration of each metal as follows: Cr (298,760±110,281 ng/m³), Ni (83,914±212,126 ng/m³), Pb (70,282±31,788 ng/m³) and Mn (67,172±115,786 ng/m³).

Cr, which is an essential metal to human body, may cause disorder of carbohydrate metabolism when it lacks. When human body is exposed to Cr for such a long time, it may cause lesions on mucous membrane and the skin.

Recently, as suggested in a study by Lee[6], many researchers have paid attention to research on cancer-causing effects of Cr. In the future, we need more studies on the management of indoor pollution of beauty shops.

Table 7 shows the results of outdoor measurement. It was found that Na (2017±1515), Cr (384.270±110.716), and Zn (200.382±212.408) have relatively high concentrations. The indoor concentrations of the major mental elements presented in table 6 were compared. More Mg, Mn, Ni, and Zn were found indoor than outdoor. According to a report by Bae[7] and et al., it was suggested that Mn was generated from indoor environment. It was thought that as most of the beauty shops were located downtown and most of the streets around beauty shops were paved, and its outdoor content was lower. When the data on concentration of heavy metals in each region were examined, the following results were obtained: residential areas, Zn 860ng/m³, Cu 220ng/m³, Pb 250ng/m³, Mn 130ng/m³ and Cd 4ng/m³, business areas, Zn 1400ng/m³, Cu 250ng/m³, Pb 360ng/m³, Mn 130ng/m³, and Cd 7ng/m³, industrial areas, Zn 1590ng/

Table 6. Measured concentration (ng/m³) of metal elements in Indoor(N=20)

	Indoor (Mean±S.D)	Minimum	Maximum
Na	1849±850	367	4525
Mg	259±209	102	1001
Cr	298.760±110.281	179.7	562.2
Mn	67.172±115.786	4.38	525.00
Ni	83.914±212.126	6.0	972.8
Cu	48.216±46.766	8.92	199.20
Zn	369.649±751.317	0.76	3325.00
As	4.439±2.307	1.351	11.390
Cd	2.953±1.853	0.050	7.331
Pb	70.282±31.788	8.96	123.900

Table 7. Measured concentration (ng/m³) of metal elements in outdoor(N=20)

	Outdoor (Mean±S.D)	Minimum	Maximum
Na	2017±1515	576	7755
Mg	218±146	82	656
Cr	384.270±110.716	198.0	611.5
Mn	45.242±26.629	9.32	112.70
Ni	83.006±137.979	7.0	621.3
Cu	48.769±48.098	12.04	240.90
Zn	200.382±212.408	37.03	957.30
As	5.289±2.651	1.760	12.590
Cd	4.152±7.328	0.756	34.430
Pb	90.438±52.377	35.49	123.90

㎥, Cu 300ng/㎥, Pb 260ng/㎥, Mn 170ng/㎥ and Cd 8ng/㎥.[8] The concentration of each heavy metal was high all in residential, business, and industrial areas, which indicates that there was much transportation in theses areas and/or many pollutants in industrial areas were found.

Table 8 presents the measured mean concentration of heavy metals in personal exposures. The relatively high concentration of Na (1619±767) and more Mg compared with those in indoor and outdoor areas were measured. The standards of lead presented by the Ministry of Environment are divided into air environment standard (yearly mean: 0.5ng/㎥) and indoor air quality management standard in respect to multi-purposed facilities (24hours: 3ng/㎥). In this study, lower concentration of lead (82.725±29.388) was measured. A study by Choi[9] reported that the exposure to 65.6ng of lead may cause death and when women use cosmetics, they may be exposed to a minimum of 70 ng/㎥ because of toner, moisturizer, foundation, compact powder, lip color and eye shadow.

Therefore, we have to develop more varied measuring techniques to identify exact concentration.

4. CONCLUSION

These measurements were carried out in 20 beauty shops which are located in Kwang-Ju and 20 subjects' exposure to air pollutants was measured. VOCs and PM_{10} density were measured inside and outside the beauty shops for 24 hours.

The questionnaires were composed of age, status, construction year, numbers of staffs, ventilation system, air conditioning methods, beauty shop location, responses to environments of beauty shops and respiratory organ symptoms.

Table 8. Concentration (ng/㎥) of metal elements in Personal exposure(N=20)

	Personal (Mean±S.D)	Minimum	Maximum
Na	1619±767	71	3670
Mg	277±227	925	1003
Cr	350.535±122.483	197.3	603.6
Mn	40.389±19.486	8.50	92.63
Ni	42.548±40.264	5.4	112.7
Cu	34.344±15.922	10.78	70.07
Zn	161.047±121.036	43.23	517.80
As	4.897±1.551	2.113	8.011
Cd	2.597±1.669	0.744	8.126
Pb	82.725±29.388	36.75	133.30

Hair dressers were aware that the air quality of beauty shop was bad. 70% of hair dressers complained of sore throat, eye irritation, nervousness and 65% of them complained of fatigue. These symptoms could be caused by chemical agents. It could be speculated that perm agents, bleach agents, dye materials and hair sprays cause sneezing, cold, and chest pain to hair dressers. The main reason for this was related to chemical materials that were used in the beauty shops and the location of the beauty shops.

Toluene and xylene were the main things to personal exposure. Hence, it is urgent to take adequate measurements to protect hair dressers and their customers from exposures to harmful air pollutants. And further research is needed to minimize the side effects of VOCs exposures. As a result of measuring heavy metals indoor, the concentrationof Na was higher, followed by Zn and Cr. For outdoor measurement, the concentration of Cr was higher, followed by Zn and Pb. In respect to personal concentration, the concentration of Na was higher, followed by Cr and Zn.

Na was found in permanent chemical agents, and Pb was mainly found in dyes and cosmetics. It was suggested that more Pb was concentrated in outdoor measurement than indoor due to automobiles, and other chemicals were generated from hair dryers, paints and wall papers.

This study showed that the mean concentration of PM_{10} inside the beauty shops was lower compared with the standard in air. Indoor air pollution may cause health problems to hair dressers and their customers. However there is a lack of understanding on harmful effects in health caused by indoor air pollution, we need further intensified studies on the following fields such as the management of PM_{10} and the pollutants of organic matters as well as heavy metals, and exact measurement of what level we are exposed to chemicals in beauty shops as well as the concentration of pollutants exposed in air.

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