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Assessment of VOCs, $PM_{10,}$ and Formaldehyde Exposure in the Hair Salons of South Korea

Shiva Raj Acharya [1*], Deog Hwan Moon [2], Yong Chul Shin [3]

[1, 2] *Graduate School of Public Health, Busan Medical Campus, Inje University, South Korea.*
[3] *Department of Environmental and Occupational Health, Inje University, South Korea.*

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***Corresponding Author:**
Shiva Raj Acharya

Email:
sameeracharya39@gmail.com

Tel:
+82 10 27417-7376

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ABSTRACT

Introduction: In hair salons, workers and customers are exposed to high concentrations of several chemical compounds used during the working environment. Volatile Organic Compounds (VOCs), particulate matter (PM_{10}), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and formaldehyde are the major chemicals that alter the indoor air quality. This study aimed to assess the indoor air quality in hair salons of Gimhae, South Korea.

Materials and Methods: To conduct the study, six hair salons were monitored for VOCs, formaldehyde, and PM_{10}. The study was conducted from August to November 2017.

Results: The findings showed higher concentrations of formaldehyde (> 0.50 ppm) and VOCs (> 0.08ppm) compared to EPA standard exposure limit; whereas PM_{10} was < 150 µg/m^3.

***Conclusion*:** Based on the findings, the ventilation systems were insufficient in the selected salons. Adequate ventilation and control facilities should be advised in applying the chemical products to observe the safety of workers and customers of hair salon and to sustain better indoor air quality.

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Introduction

Indoor air quality and pollution is one of the current global public health concerns. Volatile Organic Compounds (VOCs), particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), formaldehyde, and carbon dioxide are the major chemicals that alter the indoor air quality. Workers and customers are exposed to high concentrations of several chemicals' compounds used in the hair salons [1]. In hair salons, many chemical products are used that may lead to indoor air pollution and may result in adverse health effects. Salon workers absorb these chemicals through their skin and breathe them in as fumes build up in the salon air throughout the workday [2]. This leads to occupational health exposure to workers and customers. In expansion to CO, formaldehyde and NO_2, asbestos, radon, mercury, unstable natural compounds, allergens, tobacco smoke, microscopic organism and infections are the most supporters to indoor air contamination in industrialized nations. Chemical exposures were described in only a few studies that focused on

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the hairdressing salons. Formaldehyde was classified as a potential carcinogen that can also cause sensory and respiratory irritation [2-9]. Hypersensitive or allergic reactions, skin rashes, eye and mucous membrane irritation, and odor annoyance arise due to formaldehyde. Nausea, dizziness, eye, respiratory tract, mucous membrane irritation (rhinitis), headache, and fatigue are caused by VOCs exposure [3, 5, 7, 10, 11].

Salon specialists are uncovered to an assortment of chemicals each day in their working environment. Hair splashes, lasting waves, and various other salon items contain fixings related with asthma, dermatitis, neurological indications and indeed cancer [4,12]. Wellbeing impacts from indoor air pollutants may be experienced before long after presentation or a long time afterward [13]. A few wellbeing impacts may appear up in no time after a single introduction or rehashed exposures to a poison. These incorporate aggravation of the eyes, nose, and throat, cerebral pains, discombobulation, and weakness. Such prompt impacts are ordinarily short-term and treatable. Respiratory illnesses, heart infection, and cancer can be seriously weakening or deadly. In-depth study about this is required to way better get it the wellbeing impacts that happen after presentation to the pollutants concentrations found in homes and the impacts that happen after presentation to higher concentrations in brief periods of time [14,15].

Rationale of the study

Indoor air pollution is one of the major research priorities for researchers. Globally, many people are exposed to indoor air pollution that leads to serious health problems. Limited research was conducted in hair salons regarding indoor air quality. Thus, it might be helpful to use the findings of this study to project new regulations and programs to secure the health of workers and customers of hair salons. The main aim of this research was to assess the indoor air pollutants exposure in hair salons of Gimhae, South Korea.

Materials and Methods

Study Location

The study was conducted from August to November 2017 in Gimhae, South Korea. Gimhae is located in South Gyeongsang province of South Korea. The study location is illustrated in figure 1.

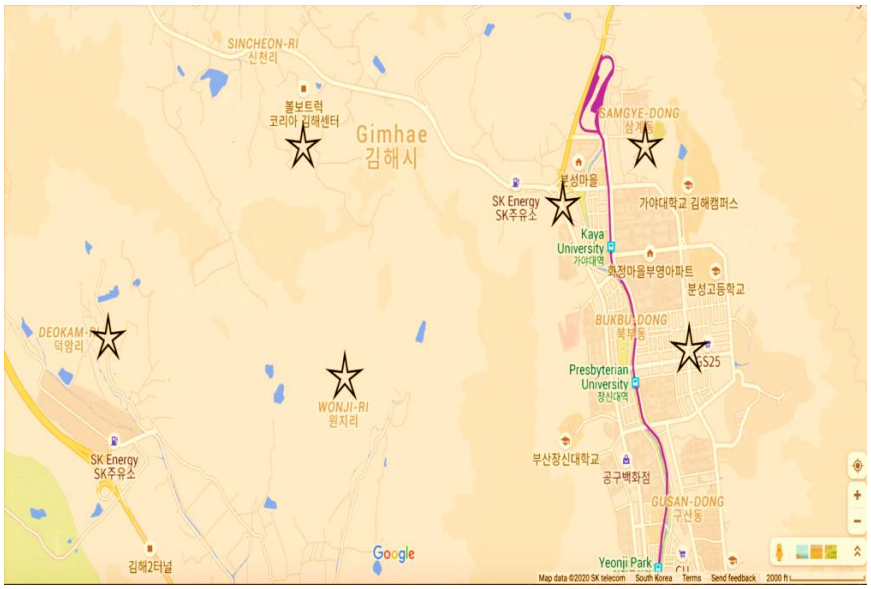

Figure 1: Study location: Black star mark the location of the selected salon

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Selection of salons

Purposive and convenience sampling technique was used for selecting the salons. Simple random sampling method was applied and six hair salons were selected from Gimhae, South Korea. Later, the indoor air quality was assessed in these salons. Chemical substances chosen for investigation were VOCs, formaldehyde, and PM_{10}.

Measurement of PM_{10}, VOCS and Formaldehyde

Mini volume PM10 sampler (ES Engineering Co., South Korea) was used to particulate matter (PM_{10}) measurement; whereas, formaldemeter (XP-308B, Saehan Inc., South Korea) was applied to monitor formaldehyde. Portable handled VOC monitor (PGM-7600, RAE Koera Inc., South Korea) was used to measure VOCs. Ventilation facilities in the salons were also checked during the assessment of indoor air quality.

Sample collection

The sample time for monitoring formaldehyde and VOCs was taken as 30 min and two consecutive measurements were performed. First measurement was done when there were no customers and the second measurement was performed in the presence of customers. The sample time for monitoring PM_{10} was taken as 6 h and one measurement were performed with no adjustment using tweezers from 1.2 - 1.5m from the floor. Pre-experiment filter was weighted as 0.1265 g.

The PM_{10} sample was allowed to dry for three days then the dried sample was weighted and enclosed in Para film, which was wrapped for three days after being enclosed. After drying for three days, sample measurement was performed and

PM_{10} was calculated using this formula:

$$\frac{(\text{Average value after measurement} - \text{Average value before measurement}) \times 10^{6}}{\text{Flux (1/min)} \times \text{time (min)} \times 10^{-3}}$$

In our study, the measured values of PM_{10}, VOCs, and formaldehyde were compared with the standard exposure limit values given by the Environmental Protection Agency [14].

Ethical issues were discussed and ethical approval was obtained from Inje University (IRB No. 17-A-00004447) and respective hair salons. The purpose and findings of the study were explained to the respondents in details.

Results

Salons with a large size had more customers per day as compared to the small salons (Table 1). The ventilation system in all selected hair salons was insufficient after observation.

Table 1: Demographic statistics of hair salon

Characteristics	Salon 1	Salon 2	Salon 3	Salon 4	Salon 5	Salon 6
Area (m^2)	23	15	25	16	15	19
No. of worker	2	4	5	3	3	5
Average customers per day	15	10	18	10	15	23
Ventilation	Not satisfying	Not satisfying	Not satisfying	Not satisfying	Not satisfying	Not satisfying

The results of formaldehyde and VOCs concentration are presented in table 2. All measurements were done inside the room. Table 2 shows the concentration level of formaldehyde and VOCs before and after the sample collection.

Table 2: Formaldehyde and VOCs concentration in selected salons

Salon	Measurement	Formaldehyde (ppm)	VOCs (ppm)
Salon 1	Before	0.07	0.32
	After	0.36	0.57
Salon 2	Before	0.17	0.46
	After	1.33	4.10
Salon 3	Before	0.19	0.40
	After	1.37	1.39
Salon 4	Before	0.22	0.51
	After	0.45	3.17
Salon 5	Before	0.03	0.23
	After	2.09	0.72
Salon 6	Before	0.26	0.36
	After	0.59	0.54

Particulate matter (PM_{10}) is another major factor influencing the indoor air quality. Particulate matter was measured by two sampling; before and after presence of the customers. Sample measurement was performed five times before and after the situation. The mean value of PM_{10} concentration before and after monitoring is displayed in table 3.

Table 3: Particulate matter (PM_{10}) concentration ($\mu g/m^3$) in selected salons

Measurement	1st	2nd	3rd	4th	5th	Mean	PM_{10}
Before	0.126	0.126	0.126	0.126	0.126	0.126	**83.33**
After	0.126	0.126	0.126	0.126	0.126	0.126	**($\mu g/m^3$)**

The results of the study as compared with the EPA standard exposure limit showed that the indoor air quality of the studied salons was inadequate and above the exposure limits as shown in table 4.

Table 4: Indoor air quality of selected salons with exposure limit

Pollutant	EPA Standard value	Measured value		Exposure limit
Formaldehyde	100 $\mu g/m^3$(0.08 ppm)	Salon 1	0.36	above
		Salon 2	1.33	
		Salon 3	1.37	
		Salon 4	0.45	
		Salon 5	2.09	
		Salon 6	0.59	
VOCs	500 $\mu g/m^3$ (0.20-0.50 ppm)	Salon 1	0.57	above
		Salon 2	4.10	
		Salon 3	1.39	
		Salon 4	3.17	
		Salon 5	0.72	
		Salon 6	0.54	
PM_{10}	150 $\mu g/m^3$	83.33 $\mu g/m^3$		below

Note: Standard value from Environmental protection agency (EPA), 2016

Discussion

Formaldehyde and VOCs were higher than the standard value in all hair salons. Regarding formaldehyde, the highest value was 2.09 ppm in salon 5 and regarding VOCs, the highest rate was 4.108 ppm in salon 2. However, the PM_{10} was found to be lower than the exposure standard. A similar study from Athens, Greece reported lower concentrations of formaldehyde than the detection limit of the method in all salons (< 0.05 ppm) [16]. Ventilation is the most essential factor in controlling the indoor air pollution. Our study

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showed that the ventilation system was insufficient in all selected hair salons. According to the previous studies, ventilation is the most crucial factor for enhancing the indoor air quality in salons [15-18].

Another finding of this study showed that exposure to VOCs had an association with increased levels of serum C-reactive protein and decreased heart rate variability (HRV) indices. The effect of VOCs exposure on the health parameters was higher during the days on which the participants were working [1], which is supported by our findings (VOCs level is above in both salons). Cora Roelofs found that introduction to a few chemical compounds was higher when hair passing on was performed. Beauticians were uncovered to minimum air levels exposure with huge number of chemical substances generally related to hair passing on [15].

This is the main source of concerns for the customers and hairdressers because of the possible health impact.

The study conducted in 12 monitored hair salons indicated that the level of VOC concentrations was mostly affected by the type of products used while the area per customer and ventilation efficiency had less impact on the VOC levels [19]. Exposure limits may well be diminished significantly by performing certain activities: utilizing great ventilation within the working region by keeping all the excellence items in an isolated room [8,9,15,17,18], closing the bundles of excellence items after utilize, and at last selecting items without solid odor [6-8,16].

According to the environmental protection agency (EPA, 2016), the exposure limits value for various chemical compounds varied depending upon the facilities. The exposure value for formaldehyde, VOCs, and PM_{10} in various facilities are shown in table 5.

Table 5: EPA standard occupational exposure limit value for Formaldehyde, VOCs and fine dust in different facilities

Facilities	Formaldehyde ($\mu g/m^3$)	VOCs ($\mu g/m^3$)	Fine dust particles ($\mu g/m^3$)
Railroad, theater, museum, library, airport	100	500	150
Hospital, nursing homes	100	200	100
Indoor parking	100	100	200

Source: Environmental protection agency (EPA), 2016 [8].

Public areas are very sensitive to the health impacts caused by different types of air pollutants. In our study, VOCs and formaldehyde were higher than the exposure level, which may be influenced by the outdoor air environment. The literature showed that outdoor air pollution had some impacts on indoor air quality in urban areas [5-7, 20, 21].

Conclusion

The concentration levels of formaldehyde and VOCs were comparatively above the EPA standard exposure limits. Ventilation system was found to be poor. Although the study was conducted in only six salons, it provides some evidences of the indoor air quality in hair salons, which may easily affect the workers and customers' health. Routine monitoring of air quality, proper ventilation systems, and low uses of beauty chemical products are highly recommended to reach the good indoor air quality in hair salons and minimize the occupational exposure.

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Conflict of Interest

We declare no conflict interests regarding this study.

References

1. Ma CM, Lin LY, Chen HW, et al. Volatile organic compounds exposure and cardiovascular effects in hair salons. Occup med. 2010;60(8):624-30.
2. Liteplo RG, Meek ME. Inhaled formaldehyde: exposure estimation, hazard characterization, and exposure-response analysis. J Toxicol Environ Health B Crit Rev. 2003;6:85-114.
3. Leino T, Tammilehto L, Luukkonen R, et al. Self-reported respiratory symptoms and diseases among hairdressers. Occup Environ Med. 1997;54(6):452–5.
4. Camfil UK. A guide to managing air quality within UK salons; 2015. Available from: https://www.camfil.com/en/insights/air-quality. [Cited April 06, 2017].
5. Mainka A, Zajusz-Zubek E. Indoor air quality in urban and rural preschools in upper Silesia, Poland: particulate matter and carbon dioxide. Int J Environ Res Public Health. 2015;12:7697-711.
6. Morawska L, Afshari A, Bae GN, et al. Indoor aerosols: from personal exposure to risk assessment. Indoor Air. 2013;23:462-87.
7. Rogula-Kozłowska W, Kozielska B, Klejnowski K, et al. Hazardous compounds in urban PM in the central part of Upper Silesia (Poland) in winter. Arch Environ Prot. 2013;39(1):53-65.
8. Salvi S. Health effects of ambient air pollution in children. Paediatr Respir Rev. 2007;8:275-80.
9. Wichmann J, Lind T, Nilsson M, et al. $PM_{2.5}$, soot and NO_2 indoor-outdoor relationships at homes, kindergartens and schools in Stockholm, Sweden. Atmos Environ. 2010;44: 4536-44.
10. Occupational Safety and Health Administration (OSHA). Indoor air quality investigation United state department of labor; 2015. Available from: https://www.osha.gov/dts/ osta/otm/otm_iii/otm_iii_ 2. html. [Cited March 15, 2016].
11. Espuga M, Munoz X, Plana E, et al. Prevalence of Possible Occupational Asthma in Hairdressers Working in Hair Salons for Women. Int Arch Allergy Immunology. 2011;155:379-88.
12. Jung PK, Lee J, Baek J, et al. The effect of work characteristics on dermatologic symptoms in hairdressers. Ann of Occup and Environ Med. 2014;26:13.
13. Banstola S, Acharya SR, Shin YC. Health problems among child labour in the brick industries of Nepal. Austin J Public Health Epidemiol. 2019;6(1):1083.
14. Environmental Protection Agency (EPA). Indoor air quality (IAQ); 2016. Available from: https: //www.epa.gov /indoor- air- qualityiaq/ publications-about-indoor-air-quality.[Cited Feb 26, 2017].
15. Ronda E, Hollund BE, Moen BE. Airborne exposure to chemical substances in hairdresser salons. Environ Monit Assess. 2009;153:83-93.
16. Hollund BE, Moen BE. Chemical exposure in hairdresser salons: effect of local exhaust ventilation. Ann Occup Hyg. 1998;42:277-82.
17. Goldin LJ, Ansher L, Berlin A, et al. Indoor air quality survey of nail salons in Boston. J Immigr Minor Health. 2014;16(3):508-14.
18. Nguyen C. Indoor air quality of nail salons in the greater Los Angeles area: Assessment of chemical and particulate matter exposures and ventilation. MS Thesis, University of California, Los Angeles; 2016.
19. Gianluigi-de G, Lucrezia-de G, Antonio M, et al. Indoor air quality in hair salons: Screening of volatile organic compounds and indicators based on health risk assessment. Atmospheric Environment. 2013;83:119-26.
20. Alexandra T, Argyro L, Stavroula C, et al. Indoor air in beauty salons and occupational health exposure of cosmetologists to chemical substances. Int J Environ Res Public Health. 2010;7:314-24.
21. Begum BA, Paul SK, Hossain MK, et al. Indoor air pollution from particulate matter emissions in different households in rural areas of Bangladesh. Build Environ. 2009;44(5):898-903.

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