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Original

Volatile Organic Compounds Concentration in the Medical Laboratories

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Abstract

Background: The aim of this study was to determine the concentration of volatile organic compounds in the air of laboratories in Kurdistan Medical Sciences University and its related factors in 2017. **Methods:** This was a descriptive-analytic study. After measuring the concentration of volatile organic compounds, the relationship of the factors affecting the concentration of these compounds was determined. In this study, eight laboratories in the health, medical and nursing faculty were entered into the study by the census method. The concentration of volatile organic compounds was measured by using the Phocheck machine of the tiger model, made in England, equipped with a PID bulb. Other variables affecting the concentration of these compounds, including temperature, moisture, type of service provided during the visit, and the type of ventilation in seasons of spring and summer were measured. Then statistical analysis was performed using SPSS v.18 software, t-test, and ANOVA. **Results:** The results of the study showed that the maximum concentrations of organic compounds were related to toluene (mean of concentration 374.61 ppb) and the lowest was related to ethylbenzene (mean of concentration 124.24 ppb). Also, the results showed that there was a significant relationship between the concentration of these compounds and the factors affecting them. **Conclusion:** Due to the lack of proper ventilation in all laboratories, it is recommended that a suitable ventilation system could be used to reduce the contamination concentration.

Keywords: Internal Air Pollution; Kurdistan; Laboratory; Medical Sciences; Volatile Organic Compounds

Introduction

Today, the industry advancement and discovery of new chemicals have created many problems in the world. One of the most common problems of air pollution is the living environment and work environment.[1,2] The quality of air in closed area is important.[3] In recent decades, the work environment has been transferred from open area to closed areas, and most people are working in office and closed areas, which is why air quality inside the closed area is very important.[3,4] These closed working areas, due to the high number of personnel, the diversity of demographic characteristics such as age and gender, the lack of adequate information on the symptoms of illnesses from indoor air pollution, hidden diseases, the presence

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of separator walls, constant changes in temperature, moisture, and the amount of inadequate air conditioning can provide stimuli and symptoms of diseases.[5-7] Typically, 20 to 60 percent of office personnel suffer from illnesses associated with the disease of the building syndrome and their work efficiency has dropped significantly.[8] Depending on the type of usage and chemical composition, the solvents can cause many complications, such as eye, lung, and skin irritation, dizziness and headache which is caused by low to moderate concentrations in the air.[9,10] Furthermore, dehydration and skin irritation, central nervous system and anesthetic suppression, coma and death, and solvents can have special effects. [9-12] For example, benzene has a liver toxicity and high exposure to it can cause damage to the bone marrow. Chronic exposure to toluene causes permanent damage to the central nervous system.[13,14] Exposure to xylene and ethylene benzene solvents cause harmful effects on the respiratory system, liver and kidneys, headache dizziness, fatigue, memory loss, and disturbance of balance.[15-18]

Benzene, toluene, ethyl benzene and xylene (BTEX) is a group of volatile organic compounds that contains benzene, toluene, ethylene benzene and xylene. Volatile Organic Compounds (VOCs) are liquids or solids that contain organic carbon and evaporate rapidly. These compounds have the highest frequency and diversity of distribution after the particle.[19] Volatile organic compounds, as presented in various studies, can be considered as the most important pollutants for assessing the air quality of the interior and exterior.[20] VOCs include a variety of air pollutants, among which there are benzene, toluene, ethyl benzene and xylene with high levels of concentration in many indoor environments.[21] Harmful effects of volatile organic compounds in indoor environments can have sensory stimuli at low and medium concentrations to toxic effects at high concentrations.[22] Also, respiratory complications, often expressed as asthma or chronic obstructive pulmonary disease (COPD), are associated with exposure to volatile organic compounds.[23] According to the International Agency for Research on Cancer (IARC) classification, benzene has a potential for carcinogenicity in its low levels, and ethyl benzene, in minor amounts, affects human health from cardio, respiratory, digestive, to hematologic disorders, skeletal disorders, and liver disease.[8,24] In a study carried out by Barkhordari et al. in Yazd on the evaluation of benzene and ethyl benzene contaminants in the air of administrative environments of hospitals in Yazd, the average concentration of benzene in mg per cubic meter, was 1.9, 0.25 and 0.4 respectively in Management room, accounting room, and staffing room which was the highest amount in the studied hospital .The average concentration of these pollutants in the office environment has been restored and has a higher work density and is statistically significant.[8]

According to extensive searches conducted in databases, no similar studies have been found to measure the concentration of volatile organic compounds in laboratories. Existence of large quantities of chemicals in laboratories and their abundant use on one hand and the extensive activity of professors, students and staff in laboratories on the other hand encouraged this study.

Methods

This descriptive-analytical study was conducted in 2017 in the laboratories of the Kurdistan Medical Sciences University. Sampling was performed by census method and by referring to 4 laboratories of faculty of medicine (microbiology, mycology, virology and anatomy), 3 laboratories of Health (microbiology, chemistry, water and sanitation) and 1 laboratory of nursing faculty (hormones) at working hours from 9 am to 1pm, in spring and summer, and it was done each time from three laboratory points. [25]The university laboratories were free from any air pollution of industries and factories, and smoking was also forbidden at the time of measurement and before measurement. At the time of the visit, no cleaning solution was used at that time. In laboratories, information was first obtained on the ventilation (observation), moisture content (using a moisture meter), temperature (using the thermometer) and the type of laboratory (observation). Then, to measure the concentration of volatile organic compounds in the air inside the laboratory in the form of portlet; phocheck, made from the UK's tiger-made and equipped with a photo ionization detector, was used which placed the device in the average mode, and after 5 minutes (according to the device catalyst), the device measured the mean value. Measurements were carried out at a distance of 1.5 meters from the wall and 1.3 meters from the floor of the building, from three points of the laboratory, in two seasons of spring and summer.[8] The SPSS software version 18 was used to examine the relationship between variables and t-test and ANOVA tests were used to analyze the data.

Results

The temperature in this study varied from 21 to 36 °C in different seasons and laboratories. In different laboratories, only one kind of natural ventilation, the door, was used, although small fans were used to replace the air, but in most cases they were either broken or inactive or not existed at all, so the ventilation was laboratory door for air exchange. Moisture content varied between 20% and 37% in different laboratories and seasons. When visiting the laboratory, various laboratory tests were carried out to measure various solutions and chemicals.

Volatile Organic Compounds

In this study, four components of volatile organic compounds, including benzene, ethyl benzene, toluene, and xylene were measured Table 5,1 .which the highest concentration of toluene was a maximum of 764 ppb and a minimum amount was 1.2 ppb. The lowest concentration was related to ethyl benzene with a maximum of 142 ppb and a minimum of less than the diagnostic limit of the device. The maximum and minimum pollutants are listed in Table 1.

The measurements were performed in 8 laboratories and 2 seasons in the spring and summer and at each visit from three points. Therefore, in each chapter, each pollutant was measured 24 times in all laboratories, and the non-parametric Man-Whitney test with the significance level (P <0.05) was used. The results of this study showed that there was a significant relationship between sampling time and concentration of toluene, xylene and ethylbenzene contaminants. Therefore, in the spring the concentrations of these organic compounds were higher than that of in summer (P <0.05) Table 2.

Table 1. The concentration of volatile organic compounds in ppb

pollutant	N	Minimum	Maximum	Mean	Standard deviation
Benzene	48	0.10	671	48.26	99.34
Toluene	48	1.20	764	374.61	258.42
Ethylbenzene	48	0	142	12.42	26.91
Xylene	48	0.10	542	238.65	187.23

P < 0.05

Table 2. The Volatile organic compound concentration according to the seasons

Variable	season	N	Mean (ppb)	p
Benzene	Spring	24	63.54	0.04
	Summer	24	32.97	
Toluene	Spring	24	442.42	0.01
	Summer	24	306.83	
Xylene	Spring	24	293.08	0.01
	Summer	24	184.22	
Ethylbenzene	Spring	24	20.37	0.04
	Summer	24	4.47	

P < 0.05

Table 3. The effect of laboratory type on the concentration of volatile organic compounds in ppb

lab	Benzene	Toluene	Ethylbenzene	Xylene
Water and sanitation	183.14	509	9.03	362.48
Medical Bacteriology	52.58	609.16	9.867	385.33
Research	44.80	544.78	9.33	322.33
Bacteriology (Health faculty)	75.4	504.61	57.03	352.81
Mycology	55.56	614.33	12.35	420
Virology	6.19	159.61	1.52	60.98
Anatomy	0.56	0.20	Below detection limit	1
Hormone	2.8	533.5	0.25	4.26

P < 0.05

Table 4. The effect of temperature and moisture on the concentration of volatile organic compounds

Parameter	Benzene	Toluene	Ethylbenzene	Xylene
Temperature	-0.27*	-0.33*	-0.24	-0.35**
Moisture	0.35**	0.41**	0.4**	0.43**

According to Table 3 and using Kruskal-Wallis test, there was a significant relationship between laboratory type with benzene, toluene, ethylbenzene and xylene concentration $P<0.05$.

Based on Table 4, the Spearman correlation test showed there was a significant correlation between temperature with toluene and xylene concentrations P <0.05, and there was a significant relationship between moisture content with the concentration of all volatile organic compounds. Therefore, the increase in moisture increased the total concentration of all components of volatile organic compounds.

Conclusion

We found that among the four studied organic compounds in this study, benzene, ethyl benzene, toluene and xylene; the highest concentration was related to toluene with a maximum value of 764 ppb and a minimum amount of 1.2 ppb. The lowest concentration of ethyl benzene with the maximum value was ppb142 and the minimum value was less than the diagnostic limit of the device. One of the major causes of this can be the early degradation and the low storage time of ethylene benzene. In a study by Jafari et al., the highest concentration was related to xylene, which was the cause of smoking in this study, and after xylene the highest concentration among BTEX compounds was related to toluene.[26]

By observing Table 3, the type of laboratory has a significant relationship with the concentration of benzene, toluene, ethyl benzene and xylene P <0.05. In a study by Barkhordari et al. with the aim of evaluating the amount of benzene-ethyl benzene pollutants in the administrative environments of the hospitals of Yazd, the amount of organic compounds in different parts of the hospital was different and in the accounting and administrative departments had the highest amount and there was a relationship with location type in the hospitals. In the study of Jafari et al., the comparison of the mean of the density of other volatile organic compounds in the study of building of units 1 and 2 showed that the average density of these two buildings is significantly different ($P<0.05$). In the study, the use of different amount of some solvents and chemicals in different laboratories can be the reason for the relationship between the type of chemical and the type of laboratory.[8,26]

According to Table 4, there was a significant relationship between temperature and toluene and xylene concentrations $P<0.05$, and there was a significant relationship between moisture content and the concentration of all volatile organic compounds. Therefore, the increase in moisture increased the concentration of all components of the volatile organic compounds. The relationship between moisture content and the concentration of organic compounds in the air has been confirmed in the Zurieh study.[27] In this study, no relation was found between the type of ventilation and the concentration of all volatile organic compounds, since in all laboratories only a natural ventilation type, a door, was used. However, there was a significant relationship between the type of ventilation and the concentration of volatile organic compounds in previous studies. In a study by Jafari et al., in two administrative buildings in Tehran, the ventilation rate had a significant relationship with the concentration of volatile organic compounds; therefore, increasing the number of windows and ventilation reduced the concentration of volatile organic compounds.[26, 28-31]

The results of this study showed that there was a significant relationship between sampling period and concentrations of toluene, xylene and ethyl benzene contaminants. Hence, in the spring the concentrations of these organic compounds were more than that of summer $P < 0.05$, which is consistent with the results of this study. In the cooler season, concentrations of pollutants were higher than the warm season. To justify this, the amount of referrals to the laboratory was higher in the spring. Cigarette smoking was prohibited in all laboratories; therefore, the effect of smoking on the concentration of volatile organic compounds was not taken. However, in the study by Sarigianis et al., smoking increased the concentration of xylene.[13]

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