ORIGINAL ARTICLE

Measurement of Air Concentrations of Particulate Matters, Volatile Organic Compounds and Formaldehyde in Lahore

Shiraz Aslam[1], Maham Javed[2], Nadeem Reyaz[3]

ABSTRACT

Background and Objective: The volatile organic compounds (VOCs) including formaldehyde (HCHO) are widely concerned due to their harmful impact on human health by productionof photochemical smog and ozone and have great impacton air quality. High air pollution level in urban areas is one of the major concerns therefore, there is need to develop cost-effective devices for measurement of VOCs in the environment. The objective of the study was to quantify the levels of these hazardous chemicals in air in major areas of Lahore.

Methods: This study was a cross-sectional descriptive study. A new multi-item pollution monitoring device (Life Basis DM 106 A) was used to carry out the readings. The areas targeted were busy areas of Lahore including Jail Road, Ferozepur Road, Lytton Road, MAO College, Kacheri, Data Darbar, Bhati Gate, Shahalmi, Davis Road and G.O.R 1.

Results: The highest VOC obtained was in the most crowded area of Lahore-the Data Darbar (10 mg/m^3) and HCHO measured was also greatest at the Data Darbar area (0.99 mg/m^3). However, G.O.R-1 showed the lowest VOCs and HCHOs measured as 0.004 mg/m^3 and 0.002 mg/m^3 respectively.Among different sizes of PM, there was a significant correlationbetween PM 1.0 and PM 10.0 ($p = 0.000$), while PM 2.5 showed a significant negative correlation ($p = 0.009$) with the relative humidity of the area.

Conclusion: A thorough knowledge of the concentrations of these pollutants and others like the PM2.5 and PM10 are paramount, in order to protect our communities from ill health.

KEYWORDS: Particulate matter, Volatile organic compounds, Formaldehyde, Environmental pollution, , Air monitoring.

How to Cite This:

Aslam S, Javed M, Reyaz N. Measurement of air concentrations of particulate matters, volatile organic compounds and formaldehyde in Lahore. Biomedica. 2020; 36 (2): 188-92.

1. Shiraz Aslam
Consultant ENT surgeon, Doctors Hospital, Lahore – Pakistan.
2. Maham Javed
Department of Pathology, University of Health Sciences, Lahore – Pakistan.
3. Nadeem Reyaz
Consultant Pathologist, Gulab Devi Chest Hospital and Teaching Institute, Lahore – Pakistan.

Corresponding Author:
Prof. Shiraz Aslam
Consultant ENT surgeon, Doctors Hospital, Lahore –Pakistan.
Email: shirazfrcs@yahoo.com.

- Received for publication: 24-09-2020
- First Revision received: 12-12-2020
- Second Revision received: 19-04-2020
- Accepted for publication: 06-06-2020

INTRODUCTION

Human activity contributes to generation of pollution, the amount and quality of which often exceed utilization abilities of the natural environment leading to loss of biosphere balance and frequently to unpredictable results.[1] Air pollutants include particulate matter (PM) of sizes equal to 1, 2.5 and 10 microns (PM 10, PM 10 and PM 2.5), CO[2], culturable airborne bacteria (CAB), total volatile organic compounds (TVOCs), formaldehyde (HCHO), nitrogen dioxide (NO2) and ozone (O3).[2] Benzene, toluene, ethylbenzene and

xylene (BTEX) are volatile organic compounds. These BTEX compounds are produced during various oil and gas operation activities including flaring, venting and operating various types of machinery. VOCs constitute an important fraction of gaseous pollutants in urbanized areas which originate from exhaust gases, evaporation of petroleum products and utilization of organic solvents thus causing serious health problems exhibiting toxic, carcinogenic (especially lung cancer on chronic exposure), mutagenic and neurotoxic properties. VOCs are believed to contribute to allergies, headaches, loss of concentration, drying and irritation of mucous membrane of nose, throat and eyes. A set of such symptoms is named as "Sick Building Syndrome (SBS)". Poor ventilation, VOC, building dampness and moulds can be associated with symptoms included in the SBS.[3]Children are recognized as being particularly vulnerable to the effects of indoor air pollutant exposure even at low concentrations as compared to adults because of the higher amount of air inhaled per unit of body. Pregnant women and elderly are also susceptible populations.

The World Health Organization (WHO) recognized VOC as the most important pollutants of indoor air. Harmless air is defined as the one, in which the total content of VOCs is lower than 100µg/m^3.[1] The indoor air quality (IAQ) has become a major concern of the public because of its adverse impact on human health, including cancer.

The results of numerous scientific investigations have shown that air quality inside office buildings and residences could be contaminated by a large variety of hazardous compounds, including combustion products, VOCs, respirable particulates, respiratory products, biologics and bioaerosols, radionuclides and odors. These indoor air pollutants (IAPs) are typically derived from building materials, furnishings, appliances, office equipment, office/residential cleaning supplies and human activities (e.g. smoking, fuel-fired cooking or space heating). Airborne HCHO is often found at non-negligible concentrations in indoor domestic environments, because it could be released from several sources (e.g. paints, coatings, wall and floor coverings, and furnishing). In addition, poor design, installation and maintenance of heating, ventilation and air conditioning (HVAC) systems may re-emit captured compounds and bioaerosols into the indoor environment.[4,5]

The present study deals with of the measurement of particulate matters, volatile organic compounds especially toluene and formaldehyde in major areas of Lahore city during mid-day.

METHODS

This was a cross-sectional descriptive study. A new multi-item pollution monitoring device (Life Basis DM 106 A) was used to carry out the readings. The areas targeted were busy areas of Lahore including Jail road, Ferozepur road, Lytton road, MAO College, Kacheri, Data Darbar, Bhati Gate, Shahalmi, Davis road and G.O.R 1.

The readings both for the VOCs and HOHCs were measured in mg/m^3 while the readings of PM were measured in µg/m^3. The device was calibrated and reset before commencing the readings. A 5 minutes period was given at each site for the reading to be taken so the pollutants have a clear chance of penetrating the sensor window. For the VOCs the representative used was toluene which is a product of car fuel.

STATISTICAL ANALYSIS

The data was entered and analyzed using Statistical Package of Social Sciences (SPSS 21). The quantity of each toxic material in the air along with relative humidity and temperature is presented for all areas. Mean + SD was calculated for all study variables. Spearman Correlation was applied to observe the relationship among the toxic compounds and between the toxic compounds, temperature, and humidity. For all analysis p value of 0.05 was considered as statistically significant with confidence level of 95%.

RESULTS

Concentrations of the VOCs and HCHOs in mg/m^3 in different areas of Lahore are given in Table-1. The highest VOC obtained was in the most crowded area of Lahore-the Data Darbar (10 mg/m^3) where, the reading went beyond the scope of the

measuring meter. Similarly, the HCHOs measured were also greatest at the Data Darbar area (0.99 mg/m^3).

Not so surprisingly, the GOR-1 area showed the lowest VOCs and HCHOs measured as 0.004 mg/m^3 and 0.002 mg/m^3 respectively. This is an area which is cordoned off from the rest of the city and where thoroughfare traffic is not allowed. There are huge trees to filter out the dust and the pollution. Although it is surrounded by large roads such as the Canal Road, Mall Road and the Jail road, but still show the lowest pollution numbers.

Highly statistically significant positive correlation was observed between concentration of HCHO and VOC *(p = 0.000)*. Among different sizes of PM there was a significant correlation between PM 1.0 and PM 10.0 *(p = 0.000),* while PM 2.5 showed a significant negative correlation *(p = 0.009)* with the relative humidity of the area meaning that there is inverse relationship between the two. None of the other correlations were statistically significant (Table-2).

Table-1: Pollutant measurements from various sites in Lahore city.

	PM 2.5 (µg/m^3)	*PM 1 (µg/m^3)*	*PM 10 (µg/m^3)*	*HCHO (mg/m^3)*	*VOC (mg/m^3)*	*Temp. (^{o}C)*	*Humidity (%)*
Jail Road	73	199	265	0.016	0.133	29.1	70
Ferozepur Road	81	190	164	0.049	0.347	32	63
Lytton Road	80	164	196	0.065	0.44	33	53
MAO College	77	170	223	0.010	0.721	30.6	57
Kacheri	77	160	200	0.093	0.629	32	66
G.C.U Road	77	198	253	0.28	1.48	30.8	57
Data Darbar	90	259	330	0.99	9.999	30.6	41
Bhati Gate	80	200	268	0.3	2.46	29.7	61
Shahalami	84	203	247	0.05	0.355	29.9	58
Bansanwala Bazar	80	185	256	0.07	0.50	28.8	53
Gawalmandi	85.5	175	232	0.03	0.2	29.6	51
Lakshmi	80.3	263	340	0.045	0.309	28.8	53
Montgomery Road	79	200	256	0.192	1.43	29.1	51
Shimla Pahari	82	189	245	0.09	0.64	28.5	52
Davis Road	84	182	223	0.06	0.4	28.9	49
G.O.R 1	61	155	207	0.002	0.004	28.8	60

¶ G.C.U = Government College University Road, M.A.O College = Muhammadan Anglo Oriental College, G.O.R = Government Officers Residence.

Table-2: Correlations between toxic compounds, temperature and humidity in selected areas of Lahore City.

		HCHO	*Temperature*	*Humidity*	*$PM_{2.5}$*	*$PM_{1.0}$*	*$PM_{10.0}$*	*VOCs*
HCHO	r_R	1.000	.231	-.276	.235	.368	.340	**.835****
	Sig	.	.390	.300	.380	.161	.197	**.000**
Temperature	r_R	.231	1.000	.284	-.039	-.132	-.412	.290
	Sig	.390	.	.287	.887	.625	.113	.276
Humidity	r_R	-.276	.284	1.000	-.628**	-.154	-.223	-.284
	Sig	.300	.287	.	**.009**	.568	.406	.287
$PM_{2.5}$	r_R	.235	-.039	**-.628****	1.000	.373	.133	.090
	Sig	.380	.887	**.009**	.	.154	.624	.739
$PM_{1.0}$	r_R	.368	-.132	-.154	.373	1.000	**.803****	.265
	Sig	.161	.625	.568	.154	.	**.000**	.321
$PM_{10.0}$	r_R	.340	-.412	-.223	.133	**.803****	1.000	.293
	Sig	.197	.113	.406	.624	**.000**	.	.271
VOCs	r_R	**.835****	.290	-.284	.090	.265	.293	1.000
	Sig	**.000**	.276	.287	.739	.321	.271	.

** = Correlation is significant at the 0.05 Level (2 tailed)

r_R = Spearman Correlation Coefficient, Sig = Level of Significance (*P*-value), HCHO= Formaldehyde, VOC = Volatile Organic Compounds

DISCUSSION

Volatile organic compounds have long been an issue of urban air quality due to their toxic effects to human health and also their roles in the formation of photochemical smog involving ozone and secondary particles. High levels of these toxic substances, in urban environment of Asian cities, especially in proximity to traffic lanes are often reported.[6]

Sensor-based Wireless Air Quality Monitoring Network (SWAQMN) is cost effective and easy to handle and can provide pollution pattern throughout the city thus helps in identifying the hotspots, which will be adequate for the policymakers to design the control strategies. A study conducted in New Delhi, India in February 2020 showed PM10to be 314μg/m^3 by using sensor polludronedevice similar to the device used in our study which shows PM10to be 330 μg/m^3.[7]

Researchers who measure the levels of toluene in Bangkok were very close to the present study considering the closeness of the pollution problem both in Lahore and Bangkok. The roadside measurement was found to be 136.45 μg/m^3 or 0.136 mg/m^3 which is very close to the reading at Jail Road in Lahore (0.133 mg/m3).[8]

Most of the levels of TVOC (toluene) measured by this study was found to be consistently above the recommended levels. The average of all 16 readings comes out to be 1.252 mg/m^3 which is exceeded the WHO and/or EU air quality guidelines.[9] According to our study the highest level which was found was 9.999mg/m^3along Data Darbar area indicating that the readings being measured were beyond the maximum scale of the measuring device.

Adverse health impacts of VOCs include eye/ throat/nose irritation, headache, nausea and damage to liver, kidneyand central nervous system. In our study workers working at various petrol pumps and small shops along the major roads in Lahore were accessed clinically and it was concluded that most of them had skin, eyes and throat irritation on and off for the last couple of years. This is consistent with other previous studies conducted.[10]

Formaldehyde is an air pollutant and because of its universal distribution, it leads to widespread human exposure and has delirious effects on human health and a proven carcinogenic. It is reported that a repeated exposure to formaldehyde will reduce the human's capacity to appreciate odours if the formaldehyde concentration reaches from 0.03 to 0.6 mg/m^3. In this this study most of the sites measured are above this level.Various studies show that formaldehyde causes upper respiratory tract irritation and on chronic exposure causes metaplastic changes in the respiratory tract and lungs.[11] It also passes through the blood-brain barrier thus affecting brain and nerve cells and alter emotional or cognitive behavior causing headache, dizziness, sleep disorders and memory loss.[12,13] In our study the workers experienced symptoms of asthma, headache and dizziness occasionally Hence, the fear of health repercussions on people who are stranded at these spots for hours such as the policemen on duty, vendours and the school children who have to walk along these heavily polluted roads.

CONCLUSION

The pollutant levels are alarmingly high in environment in leading and busiest residential and commercial areas of Lahore. It is important to carry out such pollutant measurements on a regular basis because these are "silent killers' as well and are largely ignored in our health care system as regards appropriate planning and surveillance.

LIMITATIONS OF STUDY

The measurements were taken at one point in time in different regions. Interval measurements of each particulate matter could give a more precise picture of the mean concentration of the pollutants in the environment.

ACKNOWLEDGMENT

The authors acknowledge the staff of ENT Unit at Doctor's Hospital Lahore who helped in taking the PM samples at different areas through the device.

CONFLICT OF INTEREST

None to disclose.

FINANCIAL DISCLOSURE

None to disclose.

REFERENCES

1. Szulczyński B, Gębicki J. Currently commercially available chemical sensors employed for detection of volatile organic compounds in outdoor and indoor air. Environments. 2017; 4 (1): 21-5.
2. Hwang SH, Park WM. Indoor air quality assessment with respect to culturable airborne bacteria, total volatile organic compounds, formaldehyde, PM10, CO2, NO2, and O3 in underground subway stations and parking lots. Air Qual Atmos Health. 2019; 12 (4): 435-41.
3. Norbäck D, Hashim JH, Hashim Z, Ali F. Volatile organic compounds (VOC), formaldehyde and nitrogen dioxide (NO2) in schools in Johor Bahru, Malaysia: Associations with rhinitis, ocular, throat and dermal symptoms, headache and fatigue. Sci Total Environ. 2017; 592 (1): 153-60.
4. Tsai W-T. An overview of health hazards of volatile organic compounds regulated as indoor air pollutants. Rev Environ Health. 2019; 34 (1): 81-9.
5. Lee K, Choi J-H, Lee S, Park H-J, Oh Y-J, Kim G-B, et al. Indoor levels of volatile organic compounds and formaldehyde from emission sources at elderly care centers in Korea. PloS One. 2018; 13 (6): e0197495.
6. Phuc NH, Oanh NTK. Determining factors for levels of volatile organic compounds measured in different microenvironments of a heavy traffic urban area. Sci Total Environ. 2018; 627 (4): 290-303.
7. Gulia S, Prasad P, Goyal S, Kumar R. Sensor-based Wireless Air Quality Monitoring Network (SWAQMN)-A smart tool for urban air quality management. Atmos Pollut Res. 2020. [Epub ahead of print].
8. Tunsaringkarn T, Siriwong W, Rungsiyothin A, Nopparatbundit S. Occupational exposure of gasoline station workers to BTEX compounds in Bangkok, Thailand. Int J Occup Environ Med. 2012; 3 (3): 415-9.
9. Settimo G. Existing guidelines for indoor air quality: the case study of hospital environments. Indoor air quality in healthcare facilities: Springer; 2017. p. 13-26.
10. Kashif SUR, Hanif A. Assessment of volatile organic compounds at gasoline filling stations and possible impacts on human health in Lahore, Pakistan. Pakistan Journal of Scientific & Industrial Research Series A: Phys Sci. 2019; 62 (2): 98-103.
11. Bernardini L, Barbosa E, Charão MF, Brucker N. Formaldehyde toxicity reports from in vitro and in vivo studies: a review and updated data. *D*rug Chem Toxicol. 2020; 64 (5): 1-13.
12. Afrin M, Amin T, Karim MR, Islam MR. Gross and histomorphological effects of formaldehyde on brain and lungs of Swiss albino mice. Asian J Med Biol Res. 2016; 2 (2): 229-35.
13. Zendehdel R, Fazli Z, Mazinani M. Neurotoxicity effect of formaldehyde on occupational exposure and influence of individual susceptibility to some metabolism parameters. Environ Monit *Assess*. 2016; 188 (11): 648-54.

Author's Contribution

SA: Conception of work, Acquisition and interpretation of data and drafting of manuscript.

MJ: Drafting the manuscript, Revising the work critically for important intellectual content.

NR: Acquisition and interpretation of data.

ALL AUTHORS: Approval of the final version to be published.