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Monitoring of Ambient VOC's and PM_{10} During Construction of NH-22, Bypass (Shoghi –Shimla – Dhalli) in Himachal Pradesh, India

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ABSTRACT

The study was conducted to analyse the impact of highway expansion activity on air quality. The study area was divided into four equal sites based on distances viz. Site 1, Site 2, Site 3 and Site 4. The observation on different air quality parameters at each site were recorded periodically (three times) at an interval of 15 days during pre-monsoon and post-monsoon seasons. The VOC's concentration in the study area lies in between in the range from 2.75 μg m^{-3} to 6.37 μg m^{-3}. The highest VOC's concentration of 6.15 μg m^{-3} was recorded in the pre-monsoon season and lowest of 3.09 μg m^{-3} in the post-monsoon season. The PM_{10} concentration in the study area ranged from 114.12 μg m^{-3} to 144.17 μg m^{-3}. The average highest PM_{10} concentration of 127.21 μg m^{-3} was observed in the post-monsoon season and lowest of 124.80 μg m^{-3} in the pre-monsoon season. PM_{10} concentration in all the sites was higher than the permissible limits given by NAAQS.

Key words: *Seasons, Physical, Construction, Concentration, Permissible, Ambient*

Introduction

Air pollutants are enter into the atmosphere from various sources. The concentration of pollutants in the ambient air depends not only on the quantities that are emitted but also the ability of the atmosphere, either to absorb or disperse these pollutants. Understanding the behaviour of meteorological conditions, in the planetary boundary layer is important because atmosphere is the medium in which air pollutants are transported away from the source, which is governed by the meteorological parameters such as atmospheric wind speed, wind direction, and temperature (Wexler, 1961). The pollution concentration in an area depends upon mixing depth and wind speed. The average wind speed varies more or less from place to place, from month to month and from morning to afternoon (Holzworth, 1967). The seasonal variation is also influencing the concentration of pollution. Road expansion activities have been thought to affect the quality of atmosphere and traffic emission was responsible for increase in ambient volatile organic compounds and particulate matter (Zhang *et al.,* 2017). VOCs are those chemicals having boiling point less than 260 degree Celsius and room temperature vapour pressure greater than 0.52 mmHg (Cai *et al.*, 2006). VOCs are originated from both natural and anthropogenic activities (Baudic *et al.,* 2016). The major source for ambient PM concentration is vehicle exhaust, emission from tyre and break wear and resuspension of ground dust (Bathmanabhan and Madanayak, 2010). The results of the study may be helpful to control the degradation level of air quality due to road expansion activities. In the present study, an attempt has been made to assess the prevailing concentration and trends of the, PM_{10} and VOC's in relation to anthropogenic activities.

Materials and Methods

Experimental details

In order to assess the effect of highway expansion on air quality, the area was divided into four uniform segments based on distance viz., Site 1, Site 2, Site 3, Site 4 and each site was considered as replication. The observations on different air quality parameters at each site were recorded periodically (three times) at an interval of 15 days during pre-monsoon (April and May) and post-monsoon (October and November) seasons in the year 2018 and 2019. In total there were 8 treatment combinations (4×2) which were replicated three times under randomized block design.

Sampling method

To assess the ambient air quality, the air samples were drawn by using Respirable Dust Sampler (Model No MBLRDS-002). The data on ambient air quality was recorded for eight hours at each site during day time from 9.00 am to 5.00 pm. The air quality parameters like volatile organic compounds and respirable suspended particulate matter (PM_{10}) were analyzed by following the standard procedures (NAAQMS 2012-13).

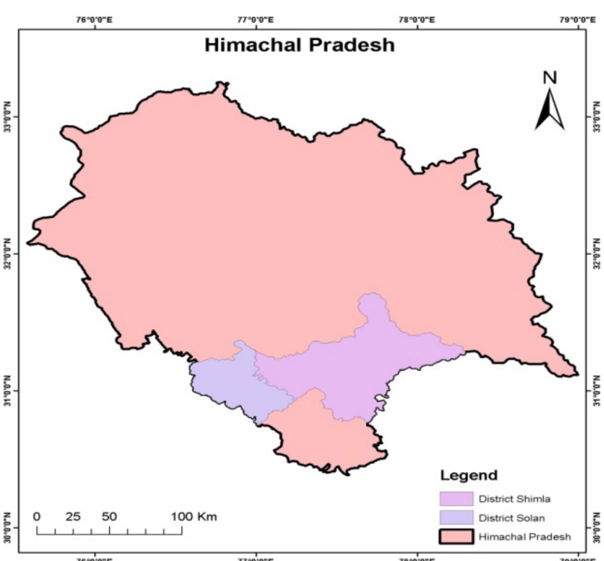

Fig. 1. Map showing the study area

Determination of Volatile Organic Compounds

The VOC's are emitted through various developmental activities and hence, its measurement in the ambient air was conducted through digitalized Environmental Perimeter Air Station (EPAS).

Determination of Respirable Suspended Particulate Matter

Respirable suspended particulate matter was analyzed by gravimetric method using Respirable dust sampler (Model No MBLRDS-002) operated at an average flow rate of 1.0-1.5 $m^3\ min^{-1}$. Ambient air laden with suspended particulates enters the system through the inlet pipe in the sampler. As the air passes through the system, non-respirable dust is separated from the air stream by centrifugal forces acting on the solid particles. These separated particulates fall through the conical hopper and gets collected in the sampling bottle placed at its bottom. The fine dust forming the respirable fraction of the Total Suspended Particulate passes through the cyclone and is carried by the air stream to the filter paper clamped between the top cover and filter adaptor assembly. The respirable dust is retained by the filter and the carrier air exhausted from the system through the blower. The data was recorded for 8 hours. The sampler was installed at a breathing height of 1.5 meter above the ground level and flow rate was noticed after 5 minutes of starting of sampling.

The volume of air sampled, V (m^3) was calculated as:

$V = Q \times T$

Where;

Q = average flow rate (m^3 per meter)

T = sampling time (minutes)

The concentration of Respirable suspended particulate matter was calculated by applying the following formula based on the method IS 5182, part IV.

$RSPM = (W_2-W_{1)})/V \times g/m^3$

$= (W_2-W_{1)})/V \times 10^6\ \mu g/m^3$

Where;

W_1 and W_2 = Initial and final weight of the filter paper (grams).

Statistical analysis

Statistical analysis under Randomized Block Design. Analysis of variance (ANOVA) was worked out and critical difference at 5% level of significance following Cochran and Cox (1967). Analysis of variance was done as per the model suggested by Panse and Sukhatme (2000). The data were analysed using MS-Excel, OPSTAT as per design of the experiment.

Results and Discussion

Distribution of VOC's in the ambient air

The data presented in Table 2 showed that VOC's concentration in the study area ranged from 2.75 μg m^{-3} to 6.37 μg m^{-3}. The maximum concentration of VOC's might be due to frequent idling and deceleration of vehicles and motor vehicles exhausts. Wu *et al.* (2016) stated that VOC's like decane, nonane, undecane, propylbenzene, isopropyl benzene, 1, 2, 3- trimethylbenzene, 1, 2, 4-trimethylbenzene and ethyltoluene were the indicators of diesel vehicles emissions. Higher VOC's concentration in post-monsoon season could be due to reduced mixing height as well as ventilation coefficient. The results showed similarity with the outcomes of Chou *et al.* (2007) and Para *et al.* (2009).

The pooled effect of both the year showed that season exerted a significant impact on VOC's concentration in the study area with the maximum (6.15 μg m^{-3}) VOC's were registered in pre-monsoon while the lowest (3.09 μg m^{-3}) evidenced in the post-monsoon season. Irrespective of seasons among different sites, the significantly highest (4.78 μg m^{-3}) VOC's were evidenced at Dhali which was found statistically at par with 4.74 μg m^{-3} at Shunghal, 4.53 μg m^{-3} at Raghanv and lowest (4.41 μg m^{-3}) at Majjhar. The two way interaction in between Season x Site was noticed to be statistically significant with highest (6.31 μg m^{-3}) VOC's at Dhali in the pre-monsoon season and lowest (2.84 μg m^{-3}) was recorded at Majjhar in the post-monsoon seasons. The three way interaction effect of the year x season x site further observed that the maximum (6.37 μg m^{-3}) concentration of VOC's at Shunghal in the post-monsoon season while the minimum (2.75 μg m^{-3}) quantity of VOC's was observed in the post monsoon at Raghanv in 2019.

Distribution of Particulate Matter in the ambient air

Data given in Table 3 indicated that highway expansion activities have significant impact on ambient air quality in the study area. The PM_{10} concentration in the study area ranged from 114.12 μg m^{-3} to 144.17 μg m^{-3}. The pooled effect of both the year on PM_{10} concentrations in the study area further indicated that irrespective of sites, the average highest (127.79 μg m^{-3}) PM_{10} concentration was evidenced in the post–monsoon season and lowest (124.21 μg m^{-3}) in the pre-monsoon season. The higher concentration of PM_{10} might be due to prevailing dry conditions, low temperature, low rainfall and moderately low relative humidity which results in poor dilution of pollutants in post-monsoon season. Further, cloud free skies prevailing during these seasons have also been reported to be responsible for generation of continental aerosols (Balakrishnaiah *et al.*, 2011). The results collaborated with the finding of Shukla *et al.* (2010) and Verma and Singh, (2014). The scrutiny of data further showed that the maximum (130.32 μg m^{-3}) PM_{10} concentration was recorded at Dhali which was statistically at par with (128.72 μg m^{-3}) at Shunghal, (125.79 μg m^{-3}) at Majjhar while minimum

Table 1. Seasonal variations in concentration of VOC's (μg m^{-3}) at different sites

	2018			2019			Pooled		
	Pre-monsoon	Post-monsoon	Mean	Pre-monsoon	Post-monsoon	Mean	Pre-monsoon	Post-monsoon	Mean
Shunghal	6.16	3.27	4.71	6.37	3.18	4.78	6.23	3.25	4.74
Raghanv	5.82	3.18	4.50	6.20	2.75	4.48	6.04	3.02	4.53
Majjhar	5.78	2.92	4.35	6.27	2.86	4.57	5.99	2.84	4.41
Dhali	6.26	3.33	4.79	6.31	3.23	4.77	6.31	3.26	4.78
Mean	6.00	3.17	4.59	6.29	3.01	4.65	6.15	3.09	4.62

$CD_{0.05}$

2018		2019		Pooled	
Distance	0.04	Distance	0.05	Distance	0.03
Season	0.03	Season	0.03	Season	0.02
Distance Season	0.06	Distance ´ Season	0.06	Distance ´ Season	0.04
				Distance ´ Season´ Year	0.06

Table 2. Seasonal variations in concentration of PM_{10} (ìg m^{-3}) at different sites

	2018			2019			Pooled		
	Pre-monsoon	Post-monsoon	Mean	Pre-monsoon	Post-monsoon	Mean	Pre-monsoon	Post-monsoon	Mean
Shunghal	125.75	138.31	132.03	127.11	123.68	125.40	124.72	132.71	128.72
Raghanv	119.67	122.73	121.20	118.77	115.54	117.16	117.61	120.75	119.18
Majjhar	126.27	125.77	126.02	126.65	124.48	125.56	125.37	126.21	125.79
Dhali	133.18	144.17	138.68	114.12	129.81	121.97	129.15	131.50	130.32
Mean	126.22	132.75	129.48	121.66	123.38	122.52	124.21	127.79	126.00

$CD_{0.05}$	2018		2019		Pooled	
	Distance	: 4.71	Distance	: 4.36	Distance	: 3.00
	Season	: 3.33	Season	: 3.17	Season	: 2.12
	Distance ´ Season	: 3.66	Distance ´ Season	: 3.16	Distance ´ Season	: 4.24
					Distance ´ Season ´ Year	: 5.21

(119.18 μg m^{-3}) was noticed at Raghanv. The variations in sites might be due to the difference in the intensity of the construction activities and the re-suspension of soil dust due to vehicular emission. The results showed similarity with the findings of Amato *et al.,* (2009) who have also noticed such enhancements in PM_{10} because of release of coarse particles from various construction activities. The season x site interaction further observed maximum (132.71 μg m^{-3}) PM_{10} concentration in post-monsoon season at Shunghal while minimum (117.61 μg m^{-3}) was evidenced at Raghanv in pre-monsoon season. The highest concentration of PM_{10} in post-monsoon season might be due to emission from the traffic and other developmental activities. The less developmental activities were responsible to lower concentration of PM_{10} in pre- monsoon season.

Conclusion

The study revealed that the spatial and seasonal changes in pollutant level during highway expansion have started to influence the physical parameter of air of the region. The highway expansion activities has significantly affected the air quality as it enhanced the level of PM_{10} from 114.12 μg m^{-3} to 144.17 μg m^{-3} in the ambient air above the prescribed limits. To mitigate the adverse effect of highway expansion activities, air quality monitoring should be done during and post-construction phase at least once in a season.

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Conflict of Interest

There is no conflict of interest for this manuscript.

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