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Research Article

Current Pollution Level and Emissions from Vehicular sector in Chandrapur District

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Abstract

Emissions from vehicles are becoming a global issue due to an increasing number of users. India is also working towards the reduction in vehicular emissions by enforcing new norms. The industrial regions like Chandrapur require separate attention as peoples are living very near to the emitting sources like factories and vehicles. In this study, the seasonal and diurnal variations of pollutants have analyzed. In addition to this, the emissions from the vehicular sector are estimated for 6 major pollutants. It has been found that the average concentration of CO, NO_x, $PM_{2.5,}$ and SO_2 is 0.37 (0.28) mg/m^3, 12.15 (5.69) ppb, 42.08 (32.45) µg/m^3 and 10.92 (3.95) µg/m^3 respectively. The annual emissions from vehicles are 6236.5, 1007.05, 238.19, 2157.46, 291.91 and 372586.05 tonnes for CO, SO_2, $PM_{2.5}$, NO_x, $CH_{4,}$ and CO_2 respectively. The detailed analysis for each type of vehicle is also done to understand the contribution to the total emission matrix.

Keywords: Pollution; $PM_{2.5}$; Concentrations; Seasonality; Greenhouse gases.

Introduction

The increasing number of vehicles is leading to a higher rate of emissions which will affect human health as well as the climate [1]. The share of the vehicular sector is significant in the global emission matrix as vehicles can emit toxic pollutants like CO as well as the Greenhouse gases (GHGs) like CO_2 [2]. The emissions from the vehicular sector are attributing to the severe air quality issue in the developing countries [3]. The particulate matters ($PM_{2.5}$, Particles with size less than 2.5 micrometers in diameter) are the major contributor for the air quality degradation and severe respiratory health issues [4]. Therefore, countries like India have enforced norms to control emissions from vehicles. The norms called Bharat Stage III, IV and VI have enforced over manufacturing companies periodically in the past years with Bharat Stage VI is the latest norms [5].

The vehicular sector is mainly responsible for the CO, NO_2, SO_2 and NO_x emissions [6-7]. The adverse effect of vehicular sector emissions may affect the human lives by direct and indirect effects. In Beijing, China annual deaths due to vehicular emission may go up to 4435 under weekday exposure but it decreases to 3462 deaths under weekend exposure with 95% confidence level [8]. However, indirect effect is more related to the global warming, the carbon dioxide and ozone emissions from vehicle may alter the radioactive forcing significantly [9].

Study over Thiruvananthapuram shows the future emissions due to vehicles are expected to rise by 65%, 71.21% and 6.67% respectively in coming decades [10]. This local emission estimation may require topredict regional impact of pollutants and GHGs. As many studies are dealing with the national level emissions which helps to prepare national level climate policies.

Various studies have conducted across the world to estimate national-level emissions from the vehicular sector. The earlier studies over India have found that the road emissions in 2003/04 are 243.81, 3.03, 2.21, 0.12, 0.71 and 0.15 kT for the CO_2, CO, NO_x, CH_4, SO_2, and $PM_{2.5}$ respectively [11]. Whereas, the study other survey-based study shows that the $PM_{2.5}$ emissions from the vehicles over India are 276 Gg/y [12].

Data and methodology

Indian Government monitors atmospheric contents at every 15 min basis at various places over India. This ground-based monitoring

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network controlled by the Central Pollution Control Board (CPCB) (https://app.cpcbccr.com/ccr/#/caaqm-dashboard-all/caaqm-landing/data) provides air pollution data for various cities. As this study focused on Chandrapur city, Maharashtra, India, the data for 4 major pollutants CO, NO_x, $PM_{2.5}$ and SO_2 are download for the period of 1 Jan 2019 to 31 Dec 2019 with every hour interval.

Whereas, the data for the number of vehicles is taken from the Census, 2011 (http://censusindia.gov.in/2011census/dchb/DCHB_A/27/2713_PART_A_DCHB_CHANDRAPUR.pdf). The major vehicle categories are Buses, Car, Jeep, Taxies, 3 wheeler Auto with 3 seater capacity, 3 wheeler Auto with 6 seater capacity, 2 wheelers (Bike and Scooty), Ambulances, School buses, 3 Wheeler Low Duty Vehicles, 4 Wheeler Low Duty Vehicles, Tractors, and Trailers. Whereas, the annual average distance traveled by each type of vehicle is assumed by considering the purpose and usage of vehicle type.

The calculation has done to estimate the emissions for six major pollutants (CO, NO_x, $PM_{2.5}$, CO2, CH_4 and SO_2) from each vehicle type using equation 1 [11]

$$Emission = \sum_{i=1}^{6}\sum_{j=1}^{13}\sum_{k=1}^{2} NV_{jk} \times AD_j \times EF_{ij} \quad (1)$$

Where, Emission = Total emission (g)
NV_{jk} = Number of vehicles of j type with k fuel (#)
AD_j = Annual distance traveled by j vehicle (km)
EF_{ij} = Emission factors of i pollutant from j vehicle (g/km)
i, j, and k stand for the pollutant, vehicle type, and fuel type.

The emission factors are the amount of individual pollutants being emitted from the vehicle by traveling a unit distance. It's very complicated and expensive to measure emission factors. So, for this study, the emission factors have been taken from the Mittal and Sharma, 2003 for CO_2 [13]; CPCB, 2007 for CO, NO_x and $PM_{2.5}$ [14]; EEA, 2001 for CH_4 [15]; Kandlikar and Ramachandran, 2000 for SO_2 [16]. Whereas, the closest emission factor has been taken for the missing vehicle types (eg. Bus, Ambulances, and School buses are considered the same). The consolidation of all the emission factors are referred from Ramachandra and Shwetmala, 2009 [11].

Results and discussion

Annual average concentrations

The CPCB data has been used to understand the variability of four major pollutants as shown in figure 1. It can be observed that the annual average value for SO_2 10.92 (3.95) µg/m^3 is not exceeding the National Ambient Air Quality Standards decided by Govt. of India which is 50 µg/m^3. However, in the months of Nov to Mar which is winter and pre-monsoon, the $PM_{2.5}$ shows more than 40 µg/m^3 which exceeds the NAAQS limit. Whereas, the annual average value for $PM_{2.5}$ is 42.08 (32.45) µg/m^3 which is not suitable for breathing. The seasonal changes show the peak concentration in the winter season. Meanwhile the least concentrated in the months of the summer monsoon (Jun, Jul, Aug, and Sep). The SO_2 concentrations are nearly similar through all the hours and seasons that may be due to its low age which is just 1-2 days. The diurnal variation gives us the important idea that all pollutants except SO_2 are having bimodal variation which shows peaks in the morning (8 am-12 pm) and night at (9 pm-11 pm). These peaks might be due to higher traffic in the morning and major cooking activities in the night.

Emissions from vehicular sector

The equation 1 has used along with emission factors to estimate the emissions of six major pollutants and GHGs from the various type of vehicles over the Chandrapur district. The results are shown in table 1, it can be observed that the vehicles which are in higher number and vehicles with higher emission factors are mainly responsible for the overall emissions. The study shows that the two-wheelers and 4 wheeler LDVs (LDV 4) are mainly responsible for the CO emission. Whereas, SO_2 is due to Buses, Taxies, and 4 wheeler LDVs. Similarly, $PM_{2.5}$ is mainly emitted from the LDV 4, Buses and two-wheelers. However, ~50% of the NO_x is being emitted from the Buses which is 1006.2 Tonnes. Meanwhile, LDV 4 and Jeeps are major CO_2 emitter with 170.98 and ~53 kT annual emissions.

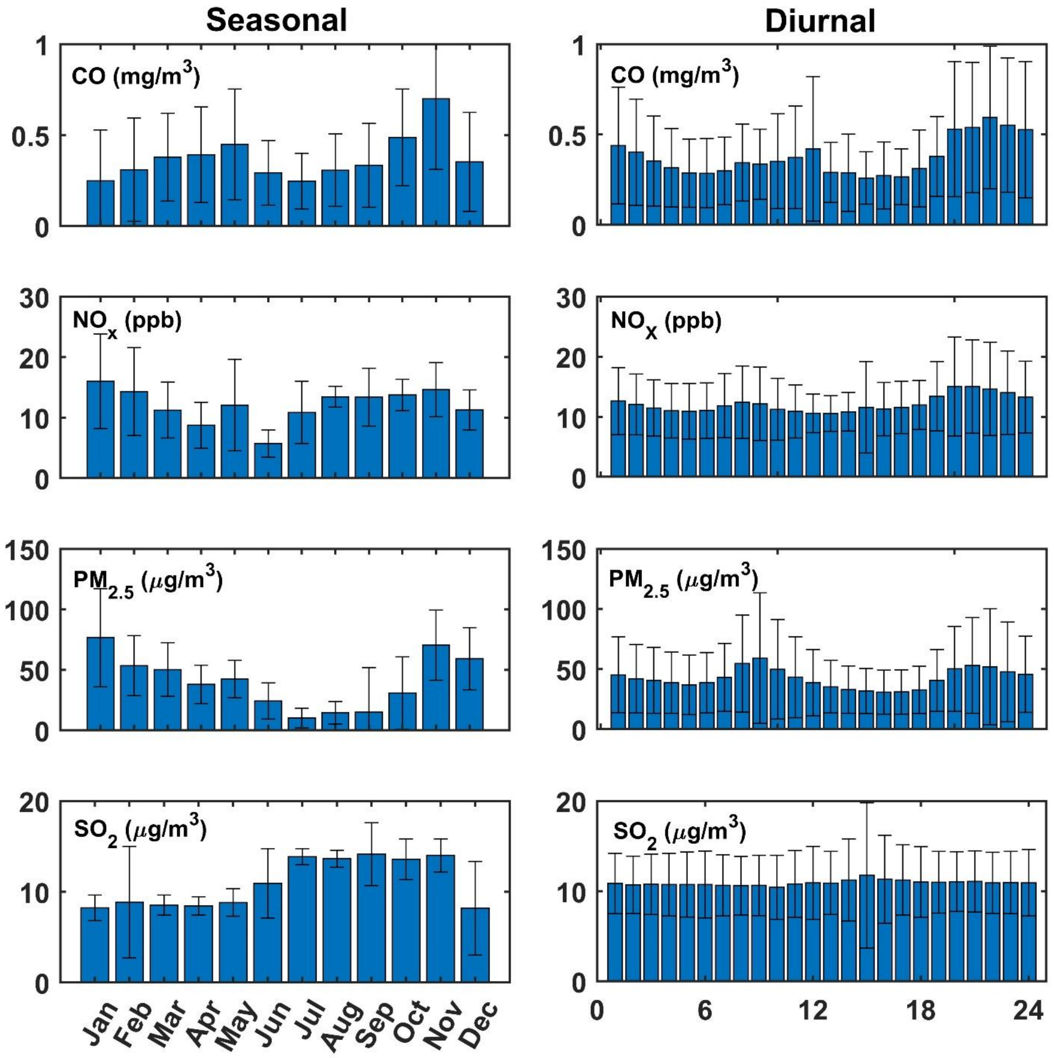

Figure 1. Seasonal and diurnal variation of pollutants (Error bar shows the standard deviation)

Table 2. Emissions of pollutants from various types of vehicles (All the units are in Tonnes)

Vehicle	CO		SO2		$PM_{2.5}$		NOx		CH4		CO2	
	D	P	D	P	D	P	D	P	D	P	D	P
BUS	301.86	0	119.07	0	46.96	0	1006.2	0	7.55	0	43199.52	0
CAR	19.31	58.15	0.52	1.56	0.29	0.88	1.95	5.87	1.66	4.99	2180.77	6567.13
JEEP	471.16	24.32	12.61	0.65	7.14	0.37	47.59	2.46	40.45	2.09	53207.86	2746.93
TAXIES	14.2	6.97	162.53	79.72	1.1	0.54	7.89	3.87	0.16	0.08	3286.97	1612.24
AUTO 3	311.24	783.15	1.77	4.45	12.21	30.71	78.12	196.55	10.99	27.64	3679.99	9259.55
AUTO 6	225.97	0	1.28	0	8.86	0	56.71	0	7.98	0	2671.77	0
2W	1.68	1825.83	0.01	10.79	0.04	41.5	0.14	157.69	0.14	149.39	20.29	22075.93
AMBULANCE	4.26	1.36	1.68	0.54	0.66	0.21	14.18	4.54	0.11	0.03	608.97	194.75
SCHOOL BUS	8.05	0	3.17	0	1.25	0	26.82	0	0.2	0	1151.47	0
LDV 3	50.12	55.02	13.96	15.32	1.97	2.16	12.58	13.81	0.88	0.97	5063.39	5557.98
LDV 4	1692.64	20.04	471.28	5.58	66.38	0.79	424.82	5.03	29.87	0.35	170989.7	2024.74
TRACTOR	62.09	0	17.29	0	2.44	0	15.58	0	1.1	0	6272.66	0
TRAILER	299.08	0	83.27	0	11.73	0	75.06	0	5.28	0	30213.39	0
Total	3461.66	2774.84	888.44	118.61	161.03	77.16	1767.64	389.82	106.37	185.54	322546.8	50039.25
	6236.5		1007.05		238.19		2157.46		291.91		372586.05	

Conclusions

$PM_{2.5}$ is mainly responsible for the degradation of air quality over the Chandrapur city as it exceeds the NAAQS limits. The seasonal variation shows a peak in the winter, whereas, least concentration in the monsoon season. However, diurnal variability is found as bimodal as it peaks twice in a day, once at ~10 am and then at ~10 pm. This may be due to heavy vehicular activity in the morning and cooking activity in the night. 4 wheeler LDV which also includes truck seems major emitter for the CO, SO_2, and $PM_{2.5}$. Whereas, Buses are responsible for ~50% of the total annual emissions of NO_x with 1006.2 Tonnes. Similarly, two-wheelers are the major source of CH_4 with ~150 Tonnes. This study can be strong using survey-based data for annual distance traveled and experimental emission factors.

Conflict of interest

The authors declared no conflict of interest.

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