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Vehicular green house gases and non-GHG emissions through daily transport within university campus, in north-west Haryana, India

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Abstract
Due to the rapid increase in the transport sector, with diverse vehicles globally generate a huge amount of GHG and non-GHG emissions. Education hubs are considered to be least polluted in terms of air quality, however, very few studies, mostly for developed nations are available on quantification of GHG and non GHG emissions. With these facts, vehicular emission inventories were performed for vehicles commuting within Kurukshetra University campus in North-West Haryana, India. This study reports, Among the GHG emissions, CO_2 alone contributes 97.9% through different types of vehicles and among the non-GHG emissions, CO contributes 56.3% through different types of vehicles. Cars (petrol and diesel) emitted 68.3 t/year of CO_2 emission, which is 74.1% of the total CO_2emissions by other vehicles. Motor bikes contributed 36% to the total GHG and 72% to the total non-GHG emissions, respectively. In the total GHG emission, vehicles driven by diesel and petrol contributed 58% and42%, respectively. Whereas, in total non-GHG emission, vehicles driven by diesel and petrol contributed 24% and 76%, respectively. Data generated in the present study can be used as a baseline study for emissions from the vehicles commuting within the university campus. This study enables administrators and university leaders to understand, quantify, and manage the emissions as well as make informed decisions towards reducing the global warming impact of the vehicular transport in the campus through CO_2 emissions reduction.

Keywords: GHG, non- GHG emissions, transport, vehicles, university campus

Introduction
Worldwide, the issues of air quality deterioration are of major concern, which directly influences the regional and global climate. Globally, the transport sector produced 7.187 $GtCO_2eq$ of direct GHG emissions (including non-CO_2 gases) in 2012 (IEA, 2012) [9]. Increased emissions due to transport sector were responsible for approx. 23% of the total energy related CO_2 emissions by road transport between 1990 and 2010. India contributes about 6-7% CO_2 emission in the world and India's CO_2 emissions in 2012 continued to increase by 6.8% to about 2.0 billion tones, making it the now-a-day third largest CO_2 emitting country. Road transport, being the dominant mode of transport in the country, emitted 87% of the total CO_2 emission from the transport sector.

The relationship between transportation and air pollutants, such as CO_2, CO, NOx and SO_2 has been well documented in a wide range of case studies (Kakouei *et al*., 2012) [11]. Reports indicate that the on-road vehicle emissions constitute the major source of atmospheric CO_2 in urban areas. In 2002, Gorham showed thatCO_2 emissions from road traffic worldwide will increase by92% between 1990 and 2020 (Nejadkoorki, *et al*., 2008) [17]. Traffic emission estimates have been used mostly to allow decision makers to manage carbon capture and storage (CCS) projects and local air quality effectively (Mittaland Sharma, 2003) [15].

In Haryana, road transport contributed about 14.9 million tons CO_2 emission in 2010. During the last decade, the number of automobiles increased and about 62% out of all road motor vehicles was2-wheeler (Guttikunda *et al*., 2013) [7]. Furthermore, crop residue burning coupled with the seviarity of air pollution (Mishra *et al*., 2014) [14]. The problem of carbon emission is more pronounced specifically in universities with a large population and large spatial size, whose design requires the use of an automobile to travel from one place to another within the campus. Similarly, the movement of vehicles within the campus consumes a high amount of fossil fuel energy, which results in the emission of GHG and non GHG.

However, better planning and implementation of policies to reduce carbon emission should be locally decided through the determination and measurement of emission sources because global warming impacts are well decided locally. Therefore, the inventory of carbon dioxide from transport within the University campus is required. Given this lack of data on atmospheric CO_2 in ambient air and the background of drastically increased motor vehicles in Kurukshetra, Haryana, India, an estimate of atmospheric CO_2 was urgently needed to provide the information necessary for developing effective CCS and air quality management. The objectives of this study were: (i) to estimate the number of vehicles plying and distance covered within the university campus; (ii) to estimate GHG and non GHG emissions from cars (petrol), cars (diesel), buses, trucks, and motorcycles; (iii) to obtain data that will contribute to establishing back ground for GHG and non GHG emissions for reference in studying the effects of the high volume of vehicular traffic in University campus.

Study area

An emission inventory of air pollutants and the most important causative factor of climate change was performed within the Kurukshetra University campus(29.9657° N, 76.8370° E), in North-west Haryana, India (Fig. 1). The campus spreads over 400 acres of land on the south bank of the holy tank Brahmasarovar. Kurukshetra district has a tropical monsoonal climate and the year is divisible into three seasons i.e., warm-wet rainy season (June to September), a cool dry winter season (October to February) and a hot dry summer (March to May). The average annual rainfall of the district is 800 mm.

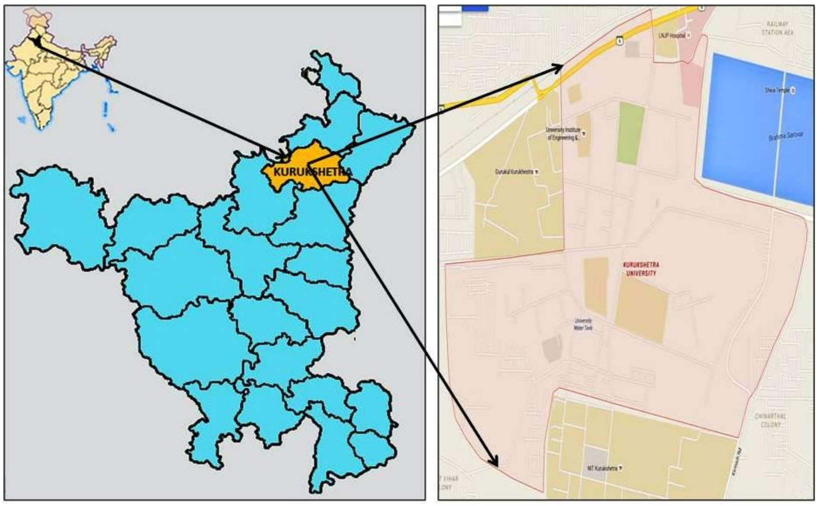

Fig 1: Location of the study area i.e. Kurukshetra University (Source: Google map)

This study was carried out in the month of March and April 2014. Questionnaire based survey was conducted regarding a number of vehicles plying in campus, total distance covered, type of vehicles. The gathered data was extrapolated for annual emissions of GHG and non GHG. For the study, different entrance gates of the university were selected for monitoring vehicular transport entering and leaving the campus for 24 hours continuously and repeated after every 15 days. To reduce the heterogeneity (day to day variation in a number of vehicles) data were collected on different days and averaged. Apart from the type of combustion engine, emission mitigation techniques, maintenance procedures and vehicle age, emissions from the transport sector depend mainly on the type of transport and fuel. The major pollutant emitted from transport is Carbon dioxide (CO_2), Methane (CH_4), Carbon monoxide (CO), Nitrogen oxides (NO_x), Sulphur dioxide (SO_2), Particulate matter (PM) and Hydrocarbon (HC). Diesel is used in public passenger (buses), cargo vehicles (trucks and lorry) and in some cars, while private two wheelers, light motor vehicles (passenger), jeeps and some cars use petrol.

Materials and Methods

Quantification of emission factors

The broad spectrum of literature including regulatory agencies available on region specific emission factors of road transport, based on the type of vehicles (Mittal and Sharma, 2003; CPCB, 2007) [14, 7] is listed in Table 1.

Table 1: Emission factors for different vehicles used in the present study

Vehicle type/ emissions (g/km)	Cars (Petrol)	Cars (diesel)	LC Vehicles (mini bus and tempo)	HC Vehicles (Bus, Truck)	Motorcycles	References
CO_2	172.95	148.8	401.3	602.0	26.6	CPCB/MoEF, (2007) [7]
CO	0.84	0.06	3.66	3.92	2.20	CPCB/MoEF, (2007) [7]
NO_X	0.09	0.28	2.12	6.53	0.19	CPCB/MoEF, (2007) [7]
CH_4	0.17	0.17	0.09	0.11	0.18	EEA, (2001)
SO_2	0.053^b	0.053	1.42	1.94	0.013	Kandlikar and Ramchandaran (2000)
PM	0.002	0.015	0.475	0.300	0.05	CPCB/MoEF, (2007) [7]
HC	0.12	0.08	1.35	0.16	1.42	CPCB/MoEF, (2007) [7]

Emissions from the road were quantified based on the number of vehicles and distance travelled in a year by different vehicle type, which is given by

$$E_i = \sum (Veh_j \times D_j) \times E_{i,j,km}$$

Where, Ei = emission of compound (i); Vehj = number of vehicles per type (j); Dj = distance travelled in a year per different vehicle type (j); Ei, j, km = emission of compound (i) from vehicle type (j) per driven kilometer.
Bottom–up approach, (Gurjar *et al*., 2004) [6] was adopted for estimation of gaseous and particulate emission based on annual average utilization for different vehicle category, number of registered vehicles and the corresponding emission factor. In the present inventory, daily vehicular emission was calculated based on distance travelled by different vehicles within the campus multiplied by the emission factor for a different vehicle.

Results and Discussion
Global emissions of $CO_2$the main cause of human-induced global warming have increased by manifolds since the industrial revolution. India's CO_2 emissions in 2012 continued to increase by6.8% to about 2.0 billion tones, making it the fourth largest CO_2 emitting country, following the European Union, and well ahead of the Russian Federation, which is the fifth largest emitting country (EDGAR, 2013) [3]. This high ranking is partly caused by the size of its population and economy. Therefore, this study becomes significant so as to know the emissions from transportation within the University campus. These education hubs are categorized under pollution free as well as silent zone.
Estimation of the number of vehicles plying and distance covered within the University campus
Kurukshetra University is emerging as technological hub and well known as a commuter campus with average commuting vehicles of 1015 vehicles plying the campus daily, and average distance covered within the campus of 1970.3 km/day. In a total number of vehicles plying per day, motor bikes rank first with 71.6%, followed by diesel car (15.6%) and petrol car (10.35%). Similarly, motor bikes (35.9%) covered maximum distance followed by diesel cars (34.4%), petrol cars (24.3%) and the rest by LC and HC vehicles (Table 2).

Table 2: Number of vehicles and distance covered on a daily and yearly basis within the University campus

Type of Vehicle	Average no. of vehicles per day	Total vehicles per year	Av. distance covered per day (km)	Total distance covered per year (km)
Cars (diesel)	157±4.0	57305	677.0±10.0	247105.0
Cars (petrol)	104±1.5	37960	499.2±9.5	182219.0
LC Vehicles (mini bus & tempo)	19±3.0	6935	29.1±6.0	10636.1
HC Vehicles (Buses and trucks)	15±3.0	5475	57.8±2.5	21100.7
Motorcycles	720±15.0	262800	707.1±7.0	258098.8
Grand total	1015	370475	1970.3	719159.5

The measurement of GHG and non-GHG emission from a different type of vehicles in the campus is a potential input to model transition to a low-carbon future and to facilitate the practice of sustainability in a manner easier to understand by university administration so as to set target and guidelines to achieve the goals of sustainability. The number and distance covered by the motorbikes followed by cars were highest and due to this, their emissions of GHG and non-GHG from these were also highest. This may be because of the craze and passion for biking among the students, however, due to lack of income source; they have bought second hand bikes having higher emissions.

Estimation of GHG and non-GHG emission from different vehicles
Transportations a major contributor to GHG and non-GHG emission with a total of 94.1 tones air pollutant, accounting for 97.9% of University total annual carbon emission. In this regard, GHG emissions by CO_2, NOx andCH_4 fora different type of vehicles commuting daily and on annual basis were categorized. The total CO_2 emissions by different vehicles were 92.1 t/year in which diesel car (39.9%) contributed the highest, followed by petrol car (34.2%). The emission of CO_2 by motor bikes, LC and HC vehicles were 7.5%, 13.8% and 4.6%, respectively (Fig. 2a).

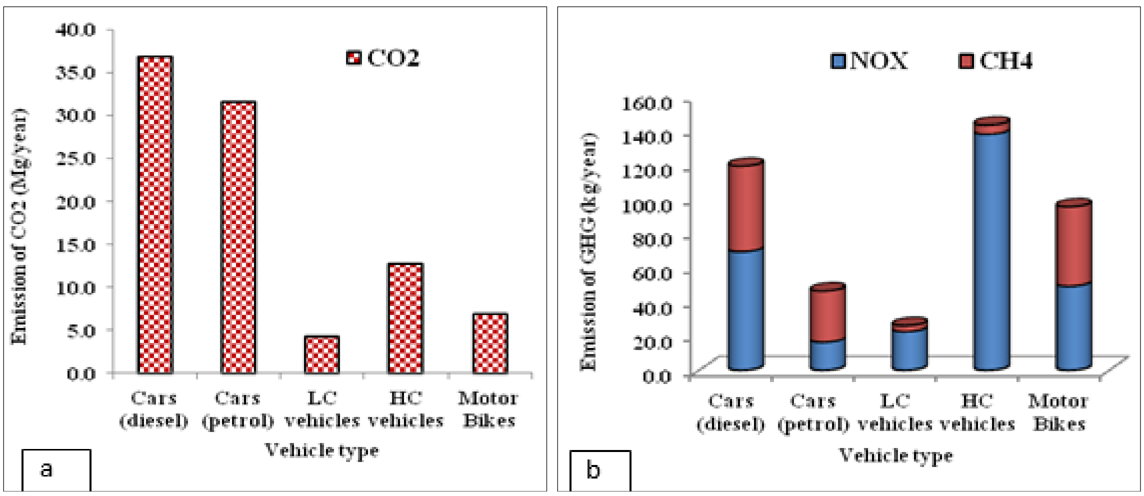

Fig 2: Contribution of (a) CO_2, (b) NOx and CH_4 in annual emissions of GHG from different vehicles types

The global warming potential of N_2O and CH_4 is 298 and 25 times higher than CO_2 (IPCC, 2007) [10]. That means even the contribution of this GHG was low, however, the impact in micro climate change will be higher. HC vehicles contributed the highest to NOx emissions (46.7%) followed by diesel cars (23.5%) and by motor bikes (16.6%), LC vehicles (7.6%) and least by petrol cars (5.6%). Similar results were also reported for high population density areas at the national scale (Kakouei *et al*., 2012, Sahu *et al*., 2014) [11, 19]. In terms of CH_4 emission, diesel cars rank first (36.9%) followed by motor bikes (34.3%), petrol car (22.1%), HC and LC vehicles (4%) and (2.6%) (Fig. 2b).

In non-GHG emissions category, SO_2, PM, HC and CO was studied within the campus for a different type of vehicles commuting daily and on annual basis. SO_2 emission was highest, followed by HC vehicles (40.3%), LC vehicles (26.2%), diesel cars (20%), petrol cars (12%), and least by motor bikes (1.6%)(Fig. 3a). Similarly, emission of hydro carbons (HC) was highest in motor bikes (86.1%), and the rest by another type of vehicles. Carbon mono oxide (CO) emission showed the similar trend with the highest emission by motor bikes (66.2%), followed by petrol car (17.9%), and the rest by another type of vehicles (Fig. 3a). Similar results were also reported at a national scale (Kandlikar and Ramchandaran, 2000; Sahu *et al*., 2014) [12, 19]. Whereas, particulate matter (PM) emission was highest by motor bikes (45.5%) followed by HC vehicles (22.3%), LC vehicles (17.8%), diesel cars (13.1%), and lowest in petrol cars (1.3%), respectively (Fig. 3b).

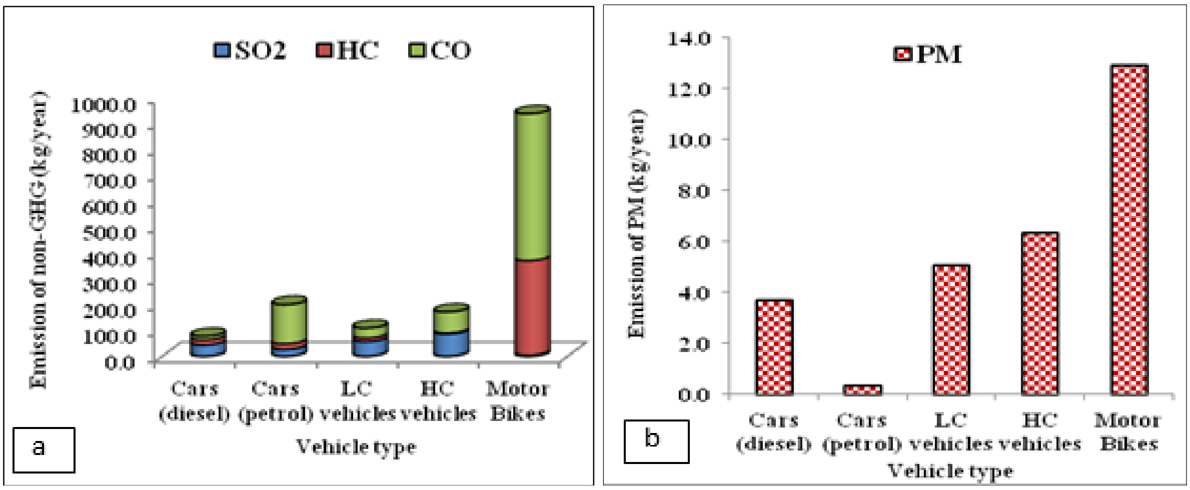

Fig 3: Contribution of (a) SO_2, HC and CO (b) PMin annual emissions of non-GHG from different vehicles types

The main factor for increasing emissions of GHG and non-GHG is the increased number of vehicles, frequency of plying of vehicles, distance covered by vehicles within the campus and the type and age of the vehicle engines (Kakouei *et al*., 2012; Mittal and Sharma, 2003; Sahu *et al*., 2014) [11, 15, 19]. The other important factor controlling the quantity and quality of GHG and non-GHG emissions is the maintenance of vehicles.

Motor bikes contributed the highest in total GHG emission (36%), followed by diesel cars (34%), petrol cars (25%), HC and LC vehicles (3%) and (2%), respectively (Fig. 4a). Similar findings were also reported by other studies (Kakouei *et al*., 2012; Mittal and Sharma, 2003; Kandlikar and Ramchandaran, 2000; Sahu *et al*., 2014) [11, 15, 19]. Motor bikes contributed 72% in total non-GHG emissions followed by diesel cars (16%), petrol cars (10%), and the rest by other vehicles (Fig. 4b).

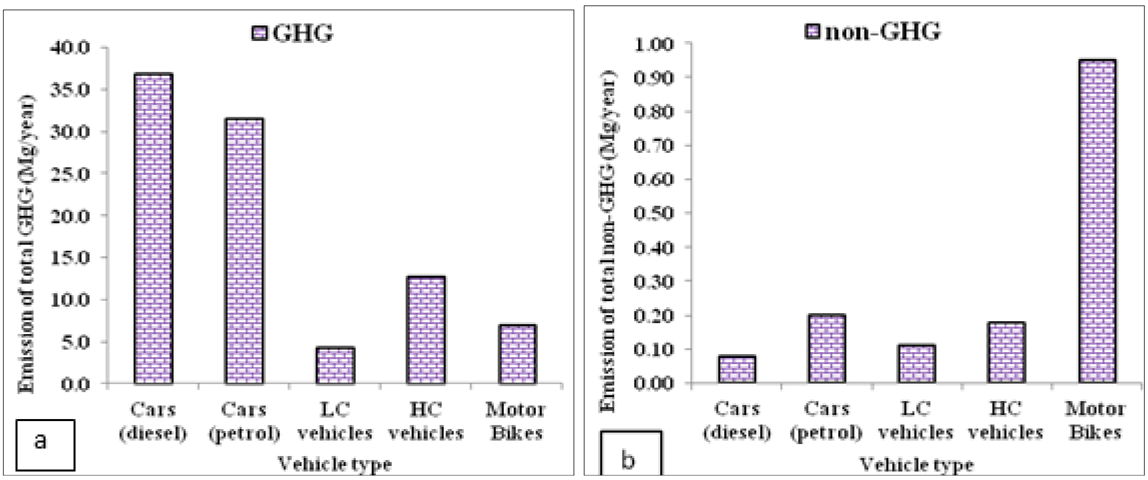

Fig 4: Annual emissions of GHG and non-GHG from different vehicles types

This trend may be because of highest population and distance covered by the subsequent vehicles. Vehicles driven by diesel and petrol contributed 58% and42%, respectively to total GHG emissions (Fig. 5a). In total non-GHG emission, vehicles driven by diesel and petrol contributed 24 and 76%, respectively (Fig. 5b).

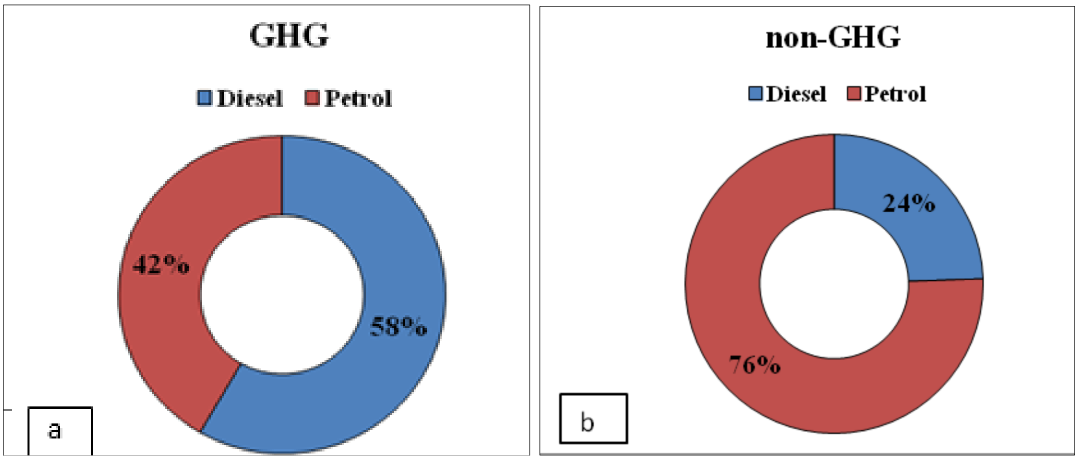

Fig 5: Contribution of diesel and petrol driven vehicles in emissions of GHG and non-GHG from different vehicles types

The present study reports in total GHG emissions, CO_2 alone contributes 97.9% through different types of vehicles, whereas in non-GHG emissions, CO contributes 56.3% through different types of vehicles. This may be because of their higher emission factor (EF) for different types of vehicles than other GHG and non-GHG. Previous and current trends indicate that CO_2 emissions from road traffic worldwide will increase by 92% between 1990 and 2020 (Gorham, 2002) [5]. Previous studies showed a drastic increase in vehicles from past few decades, leading to increased emissions at the regional and national scale. Our study reports 92.1 tons of CO_2 emissions annually within the university campus.

Congruent with previous studies in other regions, this research confirms that shortage of adequate public transport system is the basic facts responsible for the higher level of CO_2 emissions in urban areas (Metz *et al*., 2001; Reckein *et al*., 2007) [13, 18] and can have similar implications in the university campuses. This study reports higher NOx emissions by HC vehicles, followed by diesel cars, whereas CO emission was highest in motor bikes followed by petrol cars. This is mainly due to the fact that NOx has very high EFs for HCV and LCV whereas CO has high EF for motorbikes (Sahu *et al*., 2014) [19]. The highest number of motorbikes and greater EF value may be the probable reason for increased PM emission through motorbikes followed by HC vehicles. The over use of motor vehicles in any field, for every work, and use for even small distances cause the more fuel consumption and increase the demand and numbers of motor vehicles, which leads to higher emission of GHG and non GHG's. With respect to environmental perspective increasing transport and number of vehicles have a negative impact and act as a catalyst in climate change. To mitigate such air pollution green belt, roadside plantation and plantation forestry should be promoted (Arya *et al*., 2018) [2].

The knowledge of the sources and extent of GHG and non-GHG emission will facilitate the reduction of the university's contribution to global warming as a means of promoting sustainability and will enable administrators and university leaders to understand, quantify, and manage the emissions as well as make informed decisions towards reducing the global warming impact of the campus through CO_2 emissions reduction.

Abbreviations

GHG	Green House Gases
PM	Particulate Matter
CO	Carbon Monoxide
CO_2	Carbon Dioxide
HC	Hydrocarbon
NOx	Nitrogen Oxides
CH_4	Methane
SO_2	Sulphur Dioxide
CPCB	Central Pollution Control Board
CCS	Carbon Capture and Sequestration
HC	Heavy Combination Vehicles
LC	Light Combination Vehicles
MoSRTH	Ministry of Shipping, Road Transport and Highways
MoEF	The Ministry of Environment and Forests
IEA	International Energy Agency
EEA	European Environment Agency
EF	Emission Factor

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References

1. CPCB. Air quality status and trends in India. National Ambient Air Quality Monitoring Series, NAAQMS/14/1999-2000.Delhi, Transport Fuel Quality for the Year 2005. Delhi, Central Pollution Control Board, 2007
2. Rahul Arya, Mishra AK, Chaudhry Smita. Variation in Soil Properties and Carbon Stocks under Roadside Plantation and Rice-Wheat Cropping System in North Western Haryana, India. International Journal of Current Microbiology and Applied Sciences. 2018; 7(04):1939-1949, DOI:10.20546/ijcmas.2018;704.222.
3. EDGAR. Trend in CO_2 global emissions. http://edgar.jrc.ec.europa.eu/news_docs/pbl-2013-trends-in-global-co2-emissions-2013-report-1148.pdf. 2013.
4. EEA. Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook, 3rd ed. European Environment Agency, Copenhagen, 2001.
5. Gorham R. Air pollution from ground transportation: An Assessment of Causes, Strategies and Tactics, and Proposed Actions for the International Community. The Global Initiative on Transport Emissions. A Partnership

of the United Nations and the World Bank, New York, USA, 2002.
6. Gurjar BR, Aardenne V, Lelievelda JA, Mohan J. Emission estimates and trends (1990–2000) for megacity Delhi and implications. Atmospheric Environment. 2004; 38:5663-5681.
7. Guttikunda S, Lodoisamba S, Bulgansaikhan B, Dashdondog B. Particulate Pollution in Ulaanbaatar, Mongolia. Air Quality, Atmosphere and Health. 2013; 6:589-601. http://dx.doi.org/10.1007/s11869-013-0198-7.
8. IEA. International Energy Agency: Annual report.
9. https://www.iea.org/publications/freepublications/publication/IEA_Annual_Report_publicversion.pdf. 2012.
10. IPCC. Summary for Policymakers. In Climate Change. In The Physical Science Basis". Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by Solomon, S, Qin, D, Manning, M, Chen, Z, Marquis, M, Averyt, KB, Tignor, M, Miller, HL. Cambridge, United Kingdom and New York, USA: Cambridge University Press. 2007.
11. Kakouei A, Vatani A, Idris AKB. An estimation of traffic related CO_2 emissions from motor vehicles in the capital city of, Iran. Iranian Journal of Environmental Health Sciences & Engineering. 2010; 9:13.
12. Kandlikar M, Ramachandran G. The causes and consequences of particulate air pollution in urban India: A synthesis of the Science. Annual Review of Energy and the Environment. 2000; 25:629-684.
13. Metz N. Contribution of passanger cars and trucks. Austria Graz: Environmental Sustainability Conference and Exhibition. http://http://www.srcosmos.gr/ srcosmos/ showpub. aspx? aa=12523. 2001.
14. Mishra AK, Chaudhari SK, Kumar Parveen, Singh Kailash, Rai Poornima, Sharma DK. Consequences of straw burning on different carbon fractions and nutrient dynamics. Indian Farming. 2014; 64(5):11-12.
15. Mittal ML, Sharma C. Anthropogenic Emission From Energy Activities in India: Generation and Source Characterization (Part II: Emission from Vehicular Transport in India), 2003.
16. Mo SRTH. Road Transport Year book 2004/05. Transport Research Wing. Minsistry of Shipping. Road Transport and Highways. Government of India. New Delhi. http://planningcommission,nic.in/aboutus/committee/ wrkgro11/ww11_roadtpt.pdf. 2007.
17. Nejadkoorki F, Nicholson K, Lake I, Davis T. An approach for modeling CO_2 emissions from road traffic in urban areas. Sciences of the Toal Environment. 2008; 406, 269-278
18. Reckein D, maren E, Ottmar L. What parameters influence the spatial variation in CO_2 emissions from road traffic I berlin? Implicationfor urban planning to reduce anthropogenic CO2 emissions. Urban Study. 2007; 44:339-385.
19. Sahu SK, Beig G, Parkhi N. Critoical Emissions from the Largest On-Road Transport Network South Asia. Aerosol and Air Quality Research. 2014; 14:135-144.