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Emission Inventory of Vehicular Pollutants of Assam and Its Trend Analysis

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Abstract: Vehicles are a major source of air pollution in Assam as well as most of Indian cities. The rapid urbanization and industrialization in India have resulted in tremendous rise of vehicular population and its density. As a result, there is traffic congestion causing reduction in speed and more fuel consumption. So, air quality in Indian cities is degrading in an alarming rate. Central and state governments have taken various steps to improve the standard of air quality. Accurate estimation of emission inventory is very much essential for planning to reduce emissions to meet air quality goals and tracking progress of its mitigation measures. In this paper, an attempt has been made to estimate vehicular emission inventories of Assam with estimation based on total fuel consumption, emission factor and total number of vehicles registered in different categories. The method used in the present work is comprised of a combination of two different approaches *viz.* Top-down and bottom up approaches. It is revealed that CO, HC, PM, SO_2, CO_2 almost doubled during last five years. The maximum growth rate was found in case of CO, CH_4 and HC and it was minimum for NO_x. The total pollution was highest from trucks (≅65%) followed by two wheelers (≅11%). Diesel consumption was much more than total petrol consumption. Emission of pollutants *viz.* HC, CO and CH_4 are significantly higher from petrol vehicles but pollutants *viz.* CO_2, NO_x and SO_2 are significantly higher in case of diesel vehicles.

Key words: Vehicular, emission, inventory, Assam.

1. Introduction

An emission inventory is defined as an accounting of all air pollution emissions and associated data from sources within a specified area and over a specific time interval [1]. A regions economic growth is dependent on the development of basic infra structure which in turn helps in the increase of economic activities leading to increase in vehicular population and higher energy consumptions. The state of Assam is located at 26.14N and 91.77E covering an area of 78438 square kilometres having a population of 30.94 million as per 2012 census. The total road length is about 75000 KM both metalled and non-metalled. Vehicles are a major source of air pollution in Assam like most of the other Indian cities. The rapid urbanisation and industrialisation in India have resulted in tremendous rise of vehicular population. As a result, there is traffic congestion, reduction in speed leading to more fuel consumption. So, air quality in Indian cities is degrading at an alarming rate. On a global basis, vehicles account for about 14-16% of carbon dioxide (CO_2), 25-30% of oxides of Nitrogen (NO_x), 50% of hydrocarbons (HC), 60% of Lead (Pb) and as much as 60% of carbon monoxides (CO) of the anthropogenic emissions [2]. The CO_2 emission from the transportation sector in India is growing at an alarming rate. Comparing with the developing countries CO_2 emissions will be more than double by 2030 [3]. It is reported that road transportation is responsible for 80 percent of total emissions from transportation sector [4]. Among the different modes of transportation, road traffic contribute maximum as much as 73% of total emissions [5]. It is reported that vehicles in major

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metropolitan cities of India are estimated to account for 70% of CO, for 50% of HC, for 30-40% of NO_x, for 35% of SPM and for 10% of SO_2 of the total pollution load of these cities [6].

Vehicles are mobile source of pollution which occurs more in urban areas where population density is higher compare to rural areas. There is an urgent need to monitor this problem continuously and take necessary steps to improve the air quality. For this, an accurate inventory is essential. In view of the above facts, a study was undertaken to assess and estimate the vehicular emission inventory for the entire state of Assam and analyse the data year-wise, sector-wise and contribution of different types of fuel consumed.

2. Methodology

An emission inventory includes estimation of the emissions from various pollution sources in a specific geographical area. A complete inventory typically contains all regulated pollutants.

Necessity of emission inventory:

- It helps us to know how fast a particular pollutant is increasing in specific time period (Establish emission trends over time).
- It helps to fix up the actions to meet the air quality goals (Target regulatory actions).
- These data can be use to in computerised dispersion modelling to find out the air quality. (Estimate air quality through computer dispersion modelling).
- From these data we can find out what are the main sources of pollution so that we can take mitigation measures (determine significant sources of air pollutants).

The development of information on emission inventory can be carried out in two methods [7]. They are referred as i) Top down approach and ii) Bottom up approach. In the case of a top-down approach, generalized factors such as total fuel use, total population, total housing units, and total manufacturing jobs, for example, are used as indicators of emissions. Emission factors are developed that predict emissions per unit energy use or per person or such. The product of the emission factor with the relevant emissions indicator provides an estimate of emissions. The top-down approach is best used for emissions that impact global or very large regional scale problems; although it can be and has been used with respect to local air pollution problems.

In a bottom-up approach, the region of interest is divided into sectors of interest. Specific information is developed for each sector based on the specific operation within that sector. This information is then used to estimate the emissions that will occur in each sector. A bottom-up approach requires considerably greater effort than the top-down approach, but it can provide more reliable and detailed data. However, it cannot be assumed that a bottom-up inventory is better than a top-down inventory.

An emissions inventory is no better than the accuracy of the input data and the care that is taken to build the inventory. It is common to use both top-down and bottom-up methodologies to develop a single emissions inventory. Emissions from specific well defined sources are often estimated using a bottom-up approach while emissions from more generalized sources such has housing units are estimated using a top-down approach.

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

$$E_i = \sum (Veh_j \times D_j) \times E_{i,j}\ km \quad (1)$$

where, E_i = Total Emission of compound (i)

Veh_j = Number of vehicles per type (j)

D_j = Distance travelled in a year per different vehicle type (j)

$E_{i,j}$,km = Emission factor of compound (i) from vehicle type (j) per driven kilometre

Vehicular emission factor is defined as the quantity of a pollutant emitted when a vehicle runs a unit length. The emission factor depends upon the type, age, driving cycle etc. of the vehicle. To determine emission

factor, the basic approach is to specify exhaust emission rate by an "average trip" that is representative of the average driving habits of the population. The trip is usually termed as driving cycle, which is composed of a series of driving mode (idle, acceleration, cruise and deceleration), in a predetermined length of time.

In order to estimate emission inventory as accurately as possible, accurate emission factor is very essential. But, vehicle emission factors for different categories of Indian vehicles at different speed or conditions are not available in the literature. So Emission factor compiled by Ramachandra, and Shwetmala (2009) [8] is considered for the purpose (Table 1).

The data on total number of vehicles registered in Assam in different categories for last 11 years (2003-2013) were sourced from the Commissioner of Transport, Govt of Assam (Table 2). The data on total consumption of different fuels from 2007 to 2013 were collected from Indian Oil Corporation, Assam Oil Marketing Division, Guwahati and presented in Table 3. Data incorporated in Table 4 shows annual utilization of buses, Omni buses, two-wheelers, light motor vehicles (passenger), cars and jeeps, and taxi were assumed to be 100000, 100000, 6300, 33500, 12600 and 12600 km, respectively (buses, two-wheelers, car and auto rickshaw as per Singh, 2006). Similarly for trucks and Lorries, light motor vehicles (goods), and trailers and tractors were assumed as 25000 to 90000, 63000 and 21000 km per year, respectively (WGRTIPC, 2007). For other section of vehicles, annual utilization was calculated based on average of all above values. Ramachandra, and Shwetmala (2009) [8] and average fuel consumed (km per litre of fuel) was taken from their respective manuals.

Table 1 Emission factors for road vehicles (g/km).

Pollutants	Bus	Omani bases	2 wheelers	LMV	Cars & Jeep	Jeep	Trucks	LMV Goods	Tractors & trailers	others	Ref
CO_2	515.2	515.2	26.6	60.3	223.6	208.3	515.2	515.2	515.2	343.87	Mittal and Sharma, 2003
CO	3.6	3.6	2.2	5.1	1.98	0.9	3.6	5.1	5.1	3.86	CPCB, 2007
NOX	12	12	0.19	1.28	0.2	0.5	6.3	1.28	1.28	3.89	CPCB, 2007
CH4	0.09	0.09	0.18	0.18	0.17	0.01	0.09	0.09	0.09	0.11	EEA, 2001
SO_2	1.42	1.42	0.013	0.029	0.053b	10.3c	1.42	1.42	1.42	1.94	Kandlikar and Ramachandran, 2000
PM	0.56	0.56	0.05	0.2	0.03	0.07	0.28	0.2	0.2	0.24	CPCB, 2007
HC	0.87	0.87	1.42	0.14	0.25	0.13	0.87	0.14	0.14	0.54	CPCB, 2007

Source: Ramachandra, and Shwetmala (2009)

Table 2 Total number of vehicles registered in Assam

year	truck	bus	3 Wheeler	motor car	2 wheeler	tractor	tailor	jeep	govt. vehicle	motor cab	others
2003	5130	574	1801	11000	45956	479	168	405	282	931	529
2004	6464	490	2366	18212	57598	543	213	542	258	1072	714
2006	7202	602	2248	20754	64897	447	97	272	373	1231	774
2007	9205	621	2706	20226	69254	961	336	150	798	1672	737
2008	10639	706	3576	18833	57793	939	444	117	747	2039	963
2009	13172	618	3999	18912	72632	1416	477	2784	907	3298	911
2010	12417	602	5919	29546	90416	1591	498	2611	191	4408	1812
2011	15273	882	8557	17059	128099	2537	815	119	732	4073	930
2012	13713	661	5545	25337	103031	1246	487	1246	673	3602	1215
2013	14521	674	5845	26742	109501	1320	501	1320	707	3863	1278

Source: Commissioner of transport, Govt. of Assam

Table 3 Petrol and diesel consumption in Assam.

year	Petrol (KL)	Diesel (KL)
2007	72966	295795
2008	109988	408069
2009	128932	461376
2010	142977	499175
2011	158212	571413
2012	183659	639868
2013	204008	704102

Source: IOC Assam Oil marketing division.

Table 4 Annual utilisation of different vehicles [8].

VEHICLE	KM (ANNUALY)
TRUCK	90000
BUS	100000
OMNI BUS	100000
LIGHT M. VEH	33500
JEEP	12600
TAXI	12600
TRAILORS	90000
CAR	12600
2-WHEELER	6300
3 WHEELER	12600

From the above data the percentage of fuel consumed and the amount of fuel consumed by different categories of vehicles per year was calculated. Further, the total Km run by different vehicles in a year was calculated from the fuel consumption.

3. Results and Discussion

The data recorded in respect of emission of different pollutants from 2007 to 2013 is presented in Table 5. It revealed that all the pollutants are more than double in these years. The highest emission values were found in case of CO_2 followed by CO and NO_x. The lowest emission values over the years were estimated for suspended particulate matter (PM) and CH_4. However, the overall growth rates for all the pollutants are of similar pattern. This result substantiates that the fuels consumed were basically hydrocarbons resulting emission amount of CO_2. Further, it was also evident that emission values of important pollutants like CO, PM and HC followed a similar trend of increase, like that of total fuel consumption.

Table 5 Emission of pollutants during 2007 to 2013.

YEAR	CO	CH_4	SO_2	PM	HC	NO_x	CO_2
2007	8234	408	1876	442	2520	8094	659786
2008	11788	598	2595	616	3654	11176	915748
2009	13574	697	2929	698	4267	12593	1040018
2010	14888	768	3194	758	4674	13603	1130769
2011	16934	869	3638	864	5392	15508	1296596
2012	19071	981	4088	967	5959	17366	1455176
2013	20847	1068	4502	1056	6369	19051	1600459
Growth rate	109	109	110	109	107	110	110

The comparative emission of CO_2 from diesel and petrol vehicles for the year 2007 and 2013 has been shown in the Fig. 1, which indicated that the values doubled during this period. Besides, it was observed that diesel vehicles being the major segment in the transport sector emitted more amount of CO_2 as compared to petrol vehicles.

The most important pollutant CO emission was recorded from trucks which run on diesel. The Fig. 2 on the CO emission from different type of vehicles showed 40% emission from trucks followed by two wheelers 25% and motor car 18%. Two wheelers and motor cars consume less fuel as compared to trucks but their emission of pollutants particularly CO is much closer to trucks in proportion to the fuel consumption values.

Emission values depicted In the Fig. 3 showed that emissions of pollutants like HC and CH_4 were

distinctly higher from petrol vehicles while pollutants *viz.* CO_2, NO_x and SO_2 were much higher in case of diesel vehicles. The fact that consumption of diesel is much more than petrol, but emissions of CO is more or less equal to for both the cases. This might be due to the reason that permissible limit of CO emission is more in case of petrol engines.

The comparisons of different petrol vehicles as depicted in Fig. 4 revealed CO and HC were the major pollutants from petrol vehicle. The results also showed that that maximum amount of pollutants was released from 2 wheelers which was closely followed by motor car in case of CO. Comparing the emissions from different petrol vehicles, it is observed that CO and HC are the major pollutant and two wheelers are contributing maximum. The emission of HC from 2 wheelers was many times higher than motor cars and 3 wheelers.

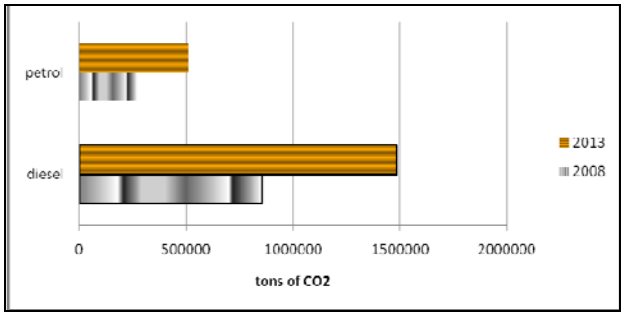

Fig. 1 CO_2 emissions from petrol and diesel vehicles (tons/year).

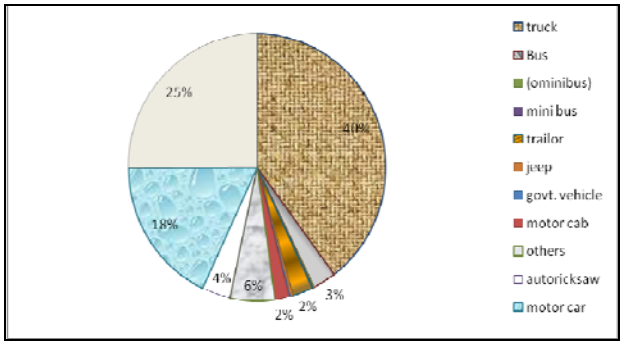

Fig. 2 CO_2 emissions from different categories of vehicles in Assam 2013.

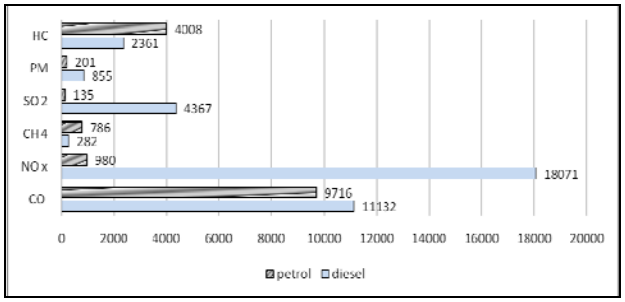

Fig. 3 Comparision of emission from petrol and diesel vehicles year 2013 (tons/year).

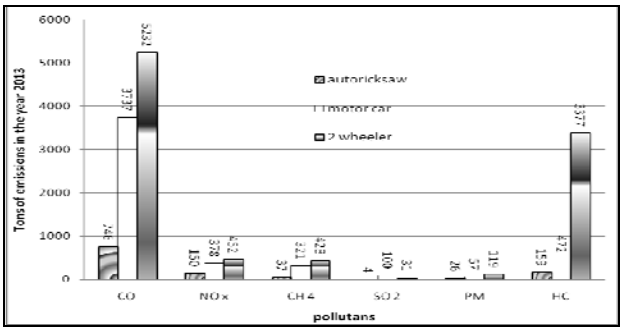

Fig. 4 Comparison of emissions petrol vehicles.

4. Conclusions

An inventory was developed through this study for the major pollutants like CO, NO_x, CH_4, SO_2, PM and HC for the state of Assam for different categories of vehicles for the period 2007-2013. The study comprised of a combination of two different approaches *viz.* Top-down and bottom up approaches. The parameters used in this study were total fuel consumption as top-down approach and segment-wise vehicular emissions as bottom-up approach. The combination of these two methods conclusively proved that all the pollutants from vehicular emissions have become more than double during the period. It is also noteworthy that the total fuel consumption had also increased more than double during the study period. It was also seen from the results that the pollutants like NO_x, SO_2 and PM were mostly emitted by the diesel vehicles but on the other hand petrol vehicles were mostly responsible for the emission of pollutants like HC and CH_4. Further, CO emission remained similar between these two broad categories of vehicle. Among the petrol vehicles, the total fuel consumption was higher in motor car than 2 wheelers but the pollutant emission from 2 wheelers was much more than other petrol vehicles.

References

[1] Utah DEQ, (2012) Emissions inventory: Definitions, accessed 31 Mar. 2012, available online at: http://www.airquality.utah.gov/Planning/Emission-Inventory/Define.htm.

[2] A. Faise and J. Aloise, Automotive air pollution in developing countries outlook control and strategies, *The Science of Total Environment* 134 (1993) 325-334.

[3] IEA 2008, World Energy Outlook.

[4] S. A. Jalihal and T. S. Reddy, Assessment of the impact of improvement measures on air quality: Case study of Delhi, *Journal of Transportation Engineering* (2006) 482-488.

[5] CPCB, Status of the vehicular pollution control programme in India, 2010.

[6] Anchal Aggarwal, Sensitive analysis of Caline 4 Highway dispersion model under mixed traffic condition, M. Tech. Dissertation, Submitted to Delhi College of Engineering, p. 142. (2011)

[7] J. Lents, M. Walsh, K. He, N. Davis, M. Osses, S. Tolvett and H. Liu, Estimating emissions from sources of air pollution, in: *Handbook of Air Quality Management*, accessed 29 Mar. 2012, available online at: http://www.aqbook.org/read/?page=72.

[8] T. Ramachandra and V. Shwetmala, Emissions from India's transport sector: State-wise synthesis, *Atmospheric Environment*, 2009, doi: 10.1016/j.atmosenv.2009.07.015.