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Research Paper

Quantifying Automobile Emissions

Engineering

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ABSTRACT

Limitation on access to data and resources to collect the necessary data has limited the institutional capacity to develop information baselines. There are various models available having varying level of complexities, which allow cities to develop their inventory. However most of these models are data intensive, only delaying the process of building a baseline.

This paper endeavours to highlight various simple methods to quantify emissions from vehicles using commonly available data with local authorities. These methods are not alternative to existing established models. The aim of this research paper is to jump start the analytical process in order to establish a robust information baseline based upon which effective decisions could be taken to reduce automobile emission significantly.

Introduction

Increasing per capita income and supply of suboptimal public transport has led to proliferation of motorized vehicles. The total motor population in India has increased from 0.30 million in 1951 to about 73 million in 2004 (Tiwari, 2011) and the share of buses declined from 11% to 1.3% between 1951 and 1997 (MoST, 2000).

The growth of motorized vehicles has increased dependency on fossil fuel based energy sources which has intensified Greenhouse Gas (GHG) emission. Between 2004 and 2007 GHG emission from transportation sector increased by 77%. In 2007 the transport sector emitted 142.04 million tons of CO_{2e} forming 12.9% of total energy sector (1100.06 million tons of CO2e) (Indian Network of Climate Change Assessment, 2010).

The transport sector in India consumes about 16.9% (36.5 mtoe: million tonnes of oil equivalent) of total energy (217 mtoe in 2005– 2006) (Ramachandra & Shwetmala, 2009). Various energy sources used in this sector are coal, diesel, petroleum (gasoline) and electricity. Road, rail and air are responsible for emission of 80%, 13% and 6% respectively (TEDDY, 2005–06). Vehicular emissions account for about 60% of the GHG's from various activities in India (Patankar, 1991).

Since vehicular emissions are ground level sources therefore they causes the maximum impact on the general population. The automobile pollution is majorly caused due to combustion. The chemical reactions occurring during ideal combustion stages may be represented as follows:

$$Fuel\ (HC) + Air\ (O2, N2) \rightarrow CO2 + H2O + \text{unaffected Nitrogen}$$

Similarly, the typical engine combustion which occurs in vehicles can be represented by the below mentioned chemical equation.

$$Fuel\ (HC) + Air\ (O2, N2) \rightarrow Unburned\ HC + NOx + CO + CO2 + H2O$$

Factors responsible for vehicular emissions

There is a direct relationship between road transport system and air pollution in a city. Vehicular emissions depend on types of engines used, congested traffic, poor road conditions, out-dated automotive technologies, traffic management systems, fuel adulteration, overloading, vehicle speed, vehicle km, age of vehicle, and emission rate. The vehicular emissions also depend on the driving modes such as idling, cruising, acceleration and deceleration.

The slow growth of road infrastructure and high growth of vehicles imply that Indian roads are reaching a saturation point in utilising the existing capacities, hence, leading to congestion. Driving on congested roads, result in higher emissions. There has been a staggering 100 fold increase in the population of motorized vehicles between 1951 and 2004, while the road network has expanded only eight times (Uddin, 2009). The infrastructure development could not commensurate with the increasing number of automobiles.

Urban sprawl has significantly increased travel time, trip length and commuting distance. Increased number of trips and commuting distances increases the amounts of emissions. In India, the trip to and from work now requires up to 3 hours a day for suburban residents of the largest cities (Gakenheimer, 2002). More time spent on road means more emission.

Emission also depends upon type of engine used as two stroke petrol engines emit more amounts of pollutants than the four stroke diesel engines. Vehicles with large engine sizes emit more pollutants. Since larger sized engines are seen in vehicles with more horsepower and more weight, these factors also contribute to the emission rates.

Methodologies for calculating emissions from vehicles

This section outlines simple ways to estimate emission from automobiles using commonly available data with the local authorities. These methods are not alternatives or undermine integrity of the established models. The advantages and disadvantages associated with each equation is also explained.

Equation 1

$$Emissions\left(\frac{tons}{year}\right) = Number\ of\ Vehicles \times Vehicle\ km\ traveled\left(\frac{km}{year}\right) \times Emission\ factor\left(\frac{gm}{km}\right) \times 10^{-6}\left(\frac{tons}{gm}\right)$$

Every city has access to registered number of vehicles but it is still hard to estimate the in-use fleet. The in-use fleet may or may not consist of registered vehicles as registered vehicles may be in use outside the city limits. Therefore estimating "number of vehicles" is the largest uncertainty which lies with this equation. However it is most commonly used equation for estimating emissions.

An emission factor is a representative value that attempts to relate the quantity of pollutants released to the quantity of pollutants released to atmosphere due to combustion of fuel, under a variety of conditions such as unloaded and loaded; cold starts; cruising; and idling. The unit of emission factor is gm/veh-km. The average value of emission factor is established after testing number of vehicles under above mentioned conditions.

Equation 2

$$Emissions\left(\frac{tons}{year}\right) = Fuel\ consumption\ per\ mode\left(\frac{liters}{year}\right) \times Fuel\ Efficiency\left(\frac{km}{liter}\right) \times Emission\ factor\left(\frac{gm}{km}\right) \times 10^{-6}\left(\frac{tons}{gm}\right)$$

When information is available on "fuel consumption" for each mode in operation, this method can be used. The data on fuel consumption can be obtained either from ministry of energy or refineries or ministry of petroleum.

"Fuel efficiency" is defined as distance travelled by vehicle per a liter of fuel. The unit of fuel efficiency is km.

Equation 3

$$Emissions\left(\frac{tons}{year}\right) = \left(Passenger\ trips\ per\ mode\left(\frac{trips}{year}\right) \Big/ Passengers\ per\ km\right) Emission\ Factor\left(\frac{gm}{km}\right) \times 10^{-6}\left(\frac{tons}{gm}\right)$$

When surveys are conducted on "Passengers per km" and "passenger trips" instead of fuel consumption and number of vehicles, this method is useful. The total vehicle kilometre of travelled can be indirectly calculated using first two parameters of the equation. This methodology does not account for goods carriage vehicles as most of the analysis in this equation is based on the passenger trips and there travel.

Conclusion

Increasing discharge of pollution into atmosphere is one of the burning issues. Over the decades various initiatives were taken to improve the quality of air in the city. But the effects of these initiatives have fallen short in keeping up with the daunt challenges posted by growing sources of air pollution.

For example the benefits of alternative fuel like Compressed Natural Gas (CNG) are outdone by increasing number of automobiles on roads and decreasing share of public transport.

In developing country such as India, there is no systematic time series data available related to pollution emission loads and trends. Establishing emission factor in Indian condition is another issue.

It is therefore necessary to provide easy access, update and maintain information on air pollution emission to develop information baseline. Once rich information baseline is developed, then comprehensive and integrated measures can be taken up to improve the quality of air in the city.

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