VEHICULAR EMISSION INVENTORIES IN CHITTAGONG METROPOLITAN

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ABSTRACT
Chittagong, the commercial capital of Bangladesh, is experiencing crucial health impacts resulting from deficient air quality. Reliable emission inventory is essential prerequisites for assessments of health impacts and analysis of possible options for air quality management. In this study, emission inventory model has been developed for five pollutants, namely PM_{10}, $PM_{2.5}$, SO_x, NO_x and CO, considering vehicular emission in Chittagong city. Diesel driven vehicles (i.e. buses, trucks) emit majority percent emission which is near about 77 percent of total emission (5264.08 tons/year). The emission factor near about 300 (tons/km/year) for the roads Dewanhat to G. E. C. is higher than the other roads considered since the ADT in that location is higher. The model which is used in this study, when fully developed and calibrated, could become a very useful policy analysis tool for air quality management.

Keywords: Air pollution; vehicular emission, ADT, PM_{10}, $PM_{2.5}$

INTRODUCTION
Road transportation, especially motor vehicles, is one of the major sources of air pollution in all large cities of the world. Extensive research linked motor vehicle induced air pollution to premature mortality in the developed world (Small and Kazimi, 1995) as well as in the developing world.

On top of it, motor vehicles are also a crucial source of carbon emissions, a vigorous greenhouse gas (GHG), adversely affecting the climate system. In the developed countries, local air pollution from motor vehicles has received attention decades ago, and the problem is alleviating (or at least not aggravating significantly) because of the enormous policy measures taken.

The main focus now is the control of GHG emissions from the road transport sector. The situation is the opposite in many developing countries where local air quality is worsening, primarily because of increasing motor vehicle ownership resulting from a high economic growth and relatively lax emissions control. While, GHG emissions are also increasing and is of some concern, the priority to the policy makers in these countries or cities is reducing local pollutants from the motor vehicles in order to reduce adverse health impacts (Wadud et al.).

Chittagong city, the second largest and port city of Bangladesh is situated within the geographical coordinates 22°05'-22°22'N and 91°40'-91°52'E Fig. 1. More than six million people live in this city within the 304.5 km^2 area with a steady increase rate of 5 % (Miah. S. 2009). The study area is stands on heart zone of Chittagong city shows on Fig. 2. Table 1 shows the details of selected roads. Being a part of sub- tropic, this area is blessed with monsoon rain. The average annual rainfall is approximately 3000 mm. The average minimum and maximum temperatures are 16-35°C respectively. Humidity is high (85%) in summer and goes down up to 65 % in winter. Wind speed is maximum (12 km/h) in monsoon and summer, and minimum (5 km/h) during winter period (G. S. Sattar, et al. 2005).

There are several source of air pollution in Bangladesh among them unfit vehicles and industries are notable. The numbers of mostly reconditioned vehicles are increasing in every year, one third of these vehicles do not have any fitness certificate (Rouf et al., 2012).Upto years 2010, the total numbers of vehicles in Bangladesh were about 14, 98,244. This number increases and reach about 24, 63,298 in the year 2015 (BRTA). The growth rate of vehicles for last five years is 13.04%. A number of ‘Export Processing Zones’ (EPZ) have been established by the local and foreign investors. Most of the industries are not following the environmental rules and regulations.

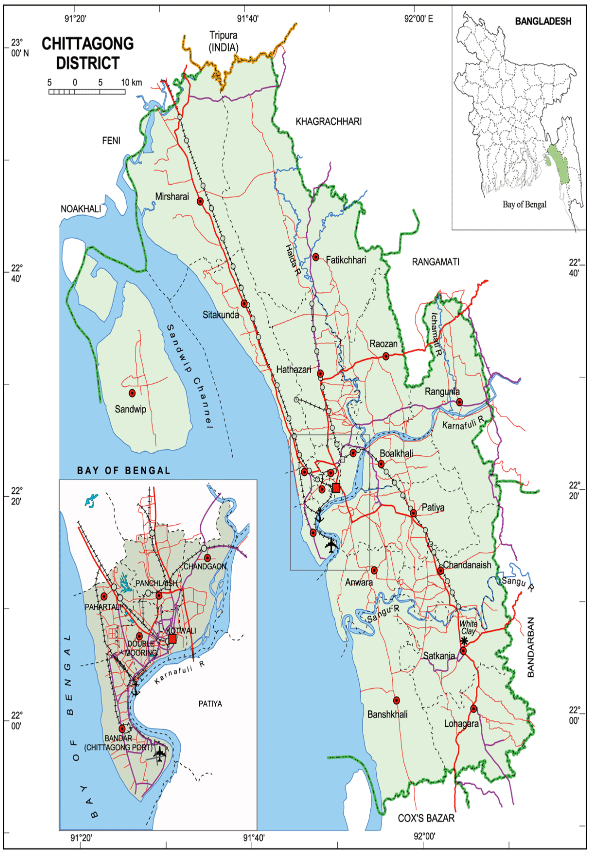

Fig. 1: Chittagong metropolitan area

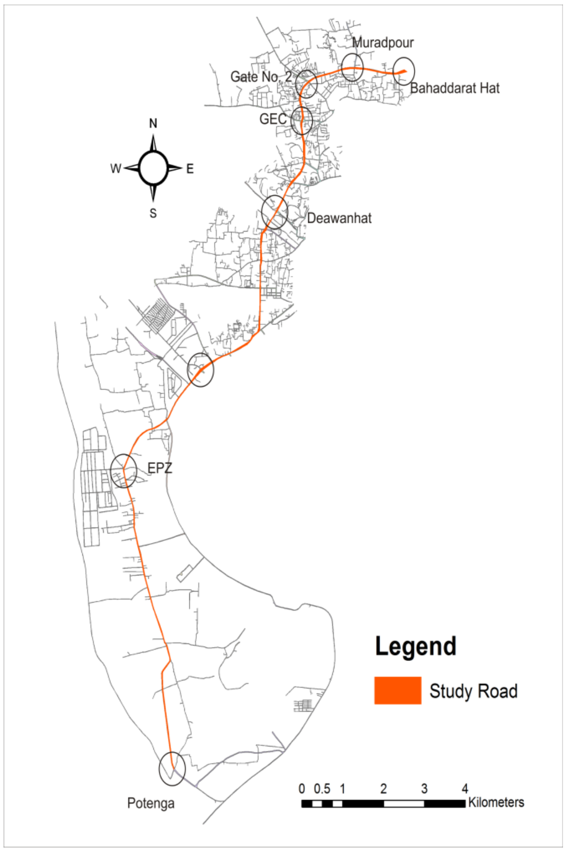

Fig. 2: Study area

Table-1: Selected Road Name & length of Chittagong City

Site No.	Site Name	Road Name	Length (km)	Latitude	Longitude	ADT	Road Type	Traffic Flow
1	Potenga to CEPZ	MA Aziz Road	4.4	22°17'30.27" N	91°46'56.81" E	34773	Secondary	Medium
2	CEPZ to Salt gola crossing	MA Aziz Road	1.5	22°17'39.03" N	91°46'57.13" E	25345	Secondary	Medium
3	Nimtoli to Salt gola crossing	Mooring Road	1	22°18'46.84" N	91°48'4.44"E	16044	Secondary	Low
4	Nimtoli to Alonkar Bus stop	Port Connecting Road	6.1	22°18'49.90" N	91°48'4.69"E	25695	Primary	Medium
5	Nimtoli to Barik Building	Mooring Road	1.3	22°19'8.89"N	91°48'42.40" E	12812	Secondary	Low
6	Barik building to Majir ghat road	Strand Road	1.8	22°19'14.94" N	91°48'53.33" E	41248	Secondary	Medium
7	Agrabad to Boro pole more	Agrabad Access Road	2.4	22°19'38.84" N	91°48'42.54" E	33739	Secondary	Medium
8	Agrabad to Barik building	Shekh Mujib Road	0.9	22°19'36.58" N	91°48'44.43" E	44699	Primary	Medium

9	Agrabad to Dewanhat	Shekh Mujib Road	1.3	22°19'39.80" N	91°48'44.56" E	65937	Primary	High
10	GEC to Dewanhat	CDA Avenue Road	2.8	22°21'31.77" N	91°49'16.78" E	83734	Primary	High
11	GEC to Probartak Mor	O. R. Nizam Road	1	22°21'32.93" N	91°49'19.77" E	17746	Diffuse	Low
12	GEC to A K Khan	Dhaka-Chittagong Hwy	5.4	22°21'32.85" N	91°49'14.72" E	20615	Secondary	Low
13	GEC to 2 No. Gate	CDA Avenue Road	1.2	22°21'35.04" N	91°49'18.06" E	55383	Primary	High
14	2 No. Gate to Oxygen	Bayazid BostamiRoad	3.5	22°21'59.85" N	91°49'21.35" E	44360	Secondary	Medium
15	2 No. gate to Probortak	Bayazid BostamiRoad	1.2	22°21'57.89" N	91°49'24.05" E	23850	Diffuse	Low
16	2 No. gate to Bahaddarhat	Dhaka-Chittagong Hwy	2.2	22°21'59.98" N	91°49'23.88" E	33285	Primary	Medium

METHODOLOGY

Like other busy city, the major sources of air pollutants in Chittagong city are motor vehicles, road dust and industries i.e. brick kilns, cement factories. In the present study, only the emissions from the motor vehicles/ traffic have been considered; efforts are underway to include other industrial emissions in the emission inventory.

Based on the road length in a particular area and the reported ADT, the activity level for each pollutant source (i.e. vehicle type) for each road was then calculated as follows:

A or VKT = L*ADT

Where, A = Activity level for each pollutant source for each road (km/day)

VKT = Vehicle Kilometers Traveled (km/day)

L = Road length (km)

ADT = Average Daily Traffic (traffic volume/day)

For vehicular emission inventory, the relevant emission factors (in gm/km units) for pollutants such as PM10, PM2.5, NOx, and SOx have been collected from available literature. Vehicular emission inventory requires estimation of the number of vehicles and/or traffic activity. Average Daily Traffic (ADT) of major roads measured by CUET has been used. Based on the length of road in a particular area and the reported ADT, the activity level for each pollutant source (i.e., vehicle type) for each road the total emission from different vehicle modes has been estimated for each road separately (T. Afrin et al., 2012). The formula used for emission estimation is given below,

Σ Emission Ei = Σ jΣ k [EFijk * Ajk]

Where, i = Type of Pollutant like PM2.5

j = Fuel Uses like CNG, Disel

k = Vehicle type like Car

EF = Emission Factor for each pollutant

A = Activity level for each pollutant source

RESULTS AND DISCUSSIONS

The estimated yearly vehicular emission for Chittagong city (specially the roads surrounding Air Port to Bahaddarhat) is considerably higher. Diesel driven vehicles (i.e. buses and trucks) are responsible for majority of PM_{10}, $PM_{2.5}$, SO_x, NO_x and CO emissions. Together buses and trucks account for about 95 percent of vehicular PM_{10} emissions, 60 percent of vehicular $PM_{2.5}$ emissions, 99 percent of vehicular SO_x emissions, 90 percent of vehicular NO_x emissions and 61 percent of vehicular CO emissions.

The ADT of different roads classified as primary, secondary and diffuse increased remarkably. The ADT in primary roads increased around 3 percent, secondary 4 percent and diffuse 7 percent than the previous study in year 2012.

Since the emission directly depends on the ADT, with the increased of ADT the per kilometer emission for all pollutants increased than the previous study. Vehicular PM_{10} emissions (tons/year) increased almost 14 percent, $PM_{2.5}$ emissions 4 percent, SOx emissions 62 percent, NO_x emissions 73 percent and CO emissions 0.05 percent than previous study.

Emissions that are released directly into the atmosphere from the tailpipes of cars, trucks etc. are the primary source of vehicular pollution. Since the rate of emission of NO_x from various vehicles is high, NO_x occupied half of the total emission which shows in Fig. 3. Fig. 4 shows the emission from specific vehicle categories where maximum portion is covered by diesel driven vehicles.

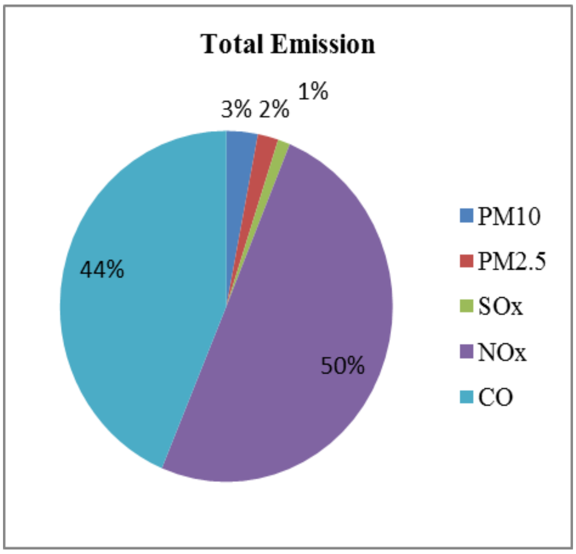

Fig.3: Total Concentration of various pollutants.

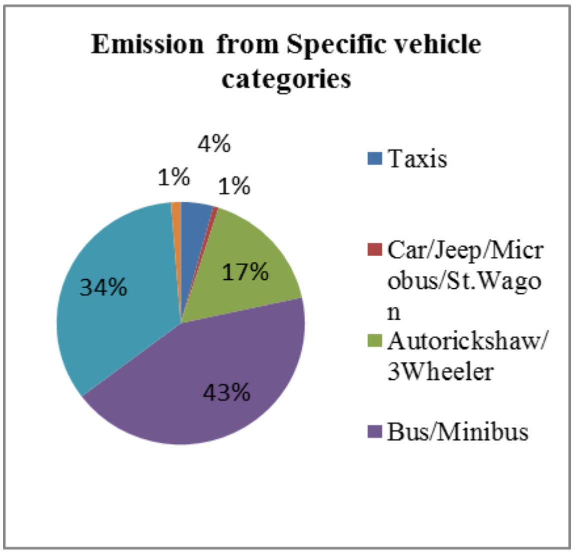

Fig.4: Emission contribution of various vehicles.

Fig. 5 and Fig. 6 shows the comparisons of average daily traffic (ADT) at different roads of Chittagong city and calculated emission factor with the present and previous study which is carried by Norwegian Institute of Air Research (NILU) in 2012 (Randall, S., et al.,2014).

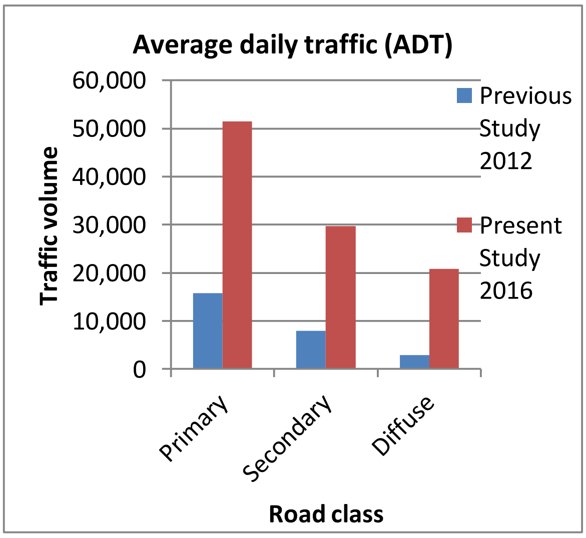

Fig.5: Comparison of average daily traffic with Previous study

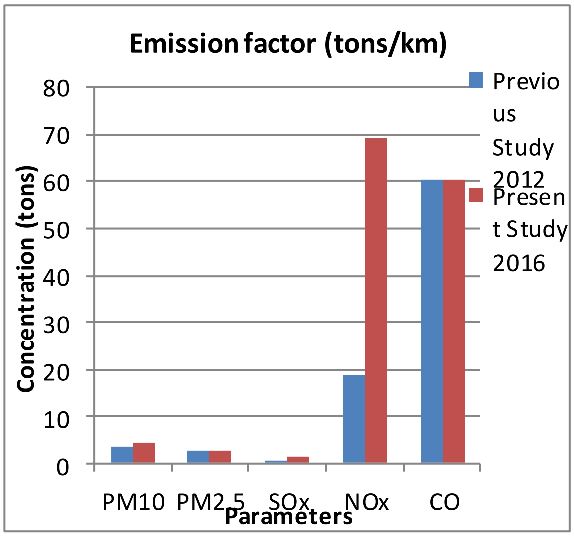

Fig.6: Comparison of calculated emission factor with previous study

[Fig. 7] shows the emission factor (tons/km/year) at several selected roads in Chittagong. The emission factor near about 300 (tons/km/year) for the roads Dewanhat to G. E. C. is higher than the other roads considered since the ADT in that location is higher.

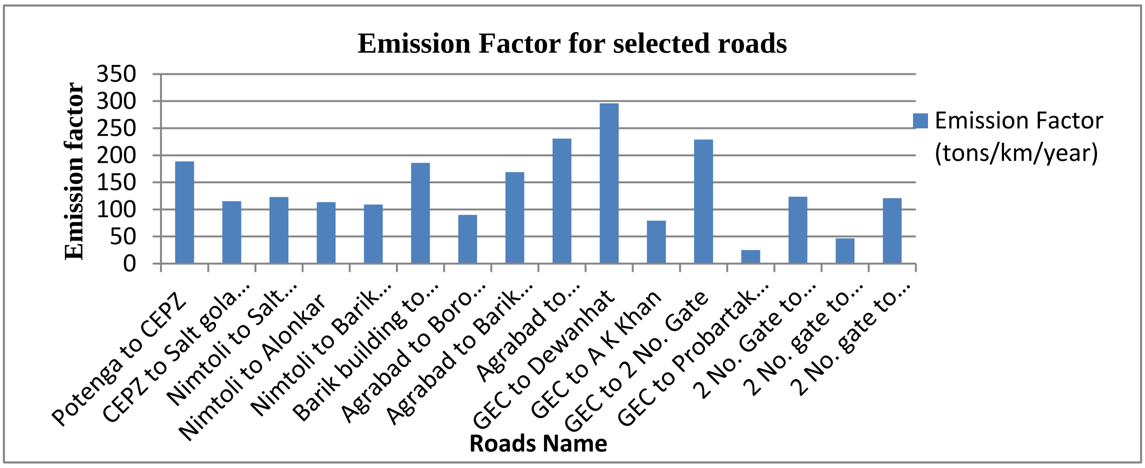

Fig.7: Emission factor (tons/km/year) at several selected roads in Chittagong

CONCLUSIONS

Bangladesh is developing day by day, as a part of its development process number of industries, vehicles infrastructures are increasing notably. Present study was on the emission inventory of Chittagong city, which shows that the ADT of different roads increased about 5 percent within four years that's why emission factor (tons/km) also increased than the previous study.

The developed emission inventory model is flexible such that it can input user defined parameters such as emission factors, activity rates (e.g. ADT for vehicle), fuel use etc. and can be easily updated as new information about the parameters become available.

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