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VEHICULAR EMISSION INVENTORY ANALYSIS OF A RESIDENTIAL AND A COMMERCIAL AREA OF DHAKA CITY

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ABSTRACT

'Sustainable Transportation System' has become one of the biggest clichés around the world nowadays; especially for a country like Bangladesh which has been ranked 4th among 91 countries with worst urban air quality in the latest air pollution monitoring report of World Health Organization (WHO). Amongst various sources of air pollution, transportation sector alone is responsible for 23% of world's Green House Gas (GHG) emissions with about 75% coming from road vehicles. This Study is aimed at determining transport (vehicular) footprint of a residential (Dhanmondi) and a commercial (Motijheel) area and comparing them with their corresponding bio-capacity. The analogy also compares six global emission parameters between these two areas which include CO_2, CH_4, SO_2, Suspended Particulate Matter, Black Carbon and Organic Carbon. Traffic volume data were collected through video footages from 8 and 10 different major links of Dhanmondi and Motijheel Thana respectively. By transcribing different types of motorized vehicles manually from footages and using vehicular expansion factors, the Annual Average Daily Traffic (AADT) of each vehicle types are calculated. The annual emissions of aforementioned six parameters are calculated using percentage share of fuel types and individual emission factors for each type of vehicles collected from international literatures and slightly modified in context of Dhaka. Then using a sequestration factor, the total area (transport footprint) required to attenuate the effects of these emissions is calculated. Comparing with the calculated bio-capacity it has been found that transport footprint exceeds by 25 times and 31 times for Dhanmondi and Motijheel area respectively.

Keywords: *Sustainable Transportation, Transport Footprint, Bio-capacity*

1. INTRODUCTION

Dhaka is the capital as well as the largest city of Bangladesh. It has an area of about 1500 km^2 and a population of about thirteen million. It is one of the most densely populated cities in the world having a population density of about 20,000 people per km^2 (BBS, 2008). The city contributes almost 40% of the national GDP (ADB and CAI-Asia, 2006).

Air pollution is one of the serious concerns of public health in a major city like Dhaka where vehicle emissions constitute one of the largest sources of air pollution. Lack of enforcement for the emission standards, poor maintenance of vehicles and insufficient traffic management resulting in very slow traffic speeds are responsible for huge amount of emissions from the vehicles. Number of vehicles has grown rapidly due to lack of public transport and economic development. During the last 7 to 8 years vehicle numbers have grown about 2.5 times due to fast economic growth resulting in increasing needs for personal Transportation and goods. The total population of registered motorized vehicles stands at 1.75 million upto june 2012 (CASE 2012). Moreover, there are innumerable unregistered vehicles plying in the city.

The Ministry of Environment and Forests says that the average speed of vehicles in Dhaka is nearly 14kmph, which is the main reason to burn more fuel and increase air pollution. According to them the average speed could come down to 4kmph by 2025 if situations remain unchanged. They think if 20 percent population is decreased, at least 1,200 to 3,500 lives can be saved and 80 to 230 million cases of respiratory diseases can be checked each year. The total economic cost is about US $800 million per year (1.1% of national GDP) due to such premature deaths and illness. (The Daily Star, 2012)

According to a study of The International Atomic Energy Agency (IAEA) the lead pollution in Bangladesh is among the world's highest during dry seasons (IAEA news brief, 1996). Scientific studies say that the density of lead in the air of Dhaka city during the dry season crosses 463 nanograms/m^3 which is considered to be the highest in the world in comparison to any other cities. Concentration of Lead in the blood of automobile drivers and office goers was found to be about 120 parts per million (Rahman et al, 2001).

Many countries have become conscious about environment pollution and come forward for the model of sustainable development first articulated at Rio Earth Summit 1992. According to the definition of United Nations World Commission on Environment and Development (WCED), "sustainable development requires that the economic and social needs of current generations be met without sacrificing the ability of future generations to achieve an acceptable quality of life." Mathis Wackernagel and William Rees proposed a method named "Ecological Footprint" at the University of British Columbia to design such sustainable model. Footprint comprises of many components such as energy, transportation, water, waste, food etc (Wackernagel and Rees, 1996). Transportation is a crucial source to measure and analyze the footprint of an urban area.

2. METHODOLOGY

This section will be dealing with the description of study area, discussion on emission inventory analysis, mathematical modelling of emission calculation and adopted fuel split percentages of different vehicles.

2.1 Study Area

This study intends to analyze the air pollution pattern of a residential and a commercial area in Dhaka city. Dhanmondi and Motijheel Thana are taken into consideration as the residential and commercial area respectively.
Any portion of a particular link which extends beyond the bounded study area was not considered in this study. Table 1 contains relative information about both of the study areas.

Table 1: Study Area

Location: Dhanmondi Thana	**Location: Motijheel Thana**
Coordinate: 23.7383° N, 90.3850° E	Coordinate: 23.7333° N, 90.4183° E
Area: 4.74 km^2	Area: 4.69 km^2
Type: Residential	Type: Commercial
Bounded by: Tejgaon and Mohammadpur Thana on the north, Lalbagh Thana on the South, Ramna Thana on the East, Hazaribagh Thana on the West.	Bounded by: Khilgaon Thana on the north, Sutrapur and Kotowali Thana on the south, Sabujbag Thana on the east and Ramna Thana on the west.
Considered Links: 1. Mirpur Road (2.9 km) 2. Sat masjid Road (1.7 km) 3. Kataban + Bir Uttam CR Dutta Road (1.95 km) 4. Panthapath Road (1.55 km) 5. Green Road (1.25 km) 6. Dhanmondi 16 (0.9 km) 7. New Elephant Road (0.73 km) 8. Dhanmondi 2 (0.72 km)	Considered Links: 1. Outer circular Road (3.15 km) 2. DIT avenue Road (2 km) 3. Sayed Nazrul Islam sharani Road (1.36 km) 4. Toyenbee circular Road (1.15 km) 5. Bangabandhu avenue, Mayor Hanif flyover Road (1.1 km) 6. VIP Road (0.94 km) 7. Bir Uttam Shamsul Alam Road (0.915 km) 8. Khilgaon Road (0.85 km) 9. Shantinagar Road (0.8 km) 10. Motijheel Road (0.74 km)

Only major links of these two areas have been taken into considerations in this study.

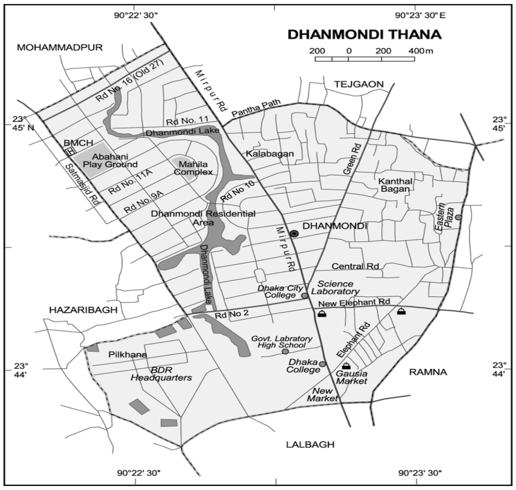

Figure 1: Dhanmondi Thana

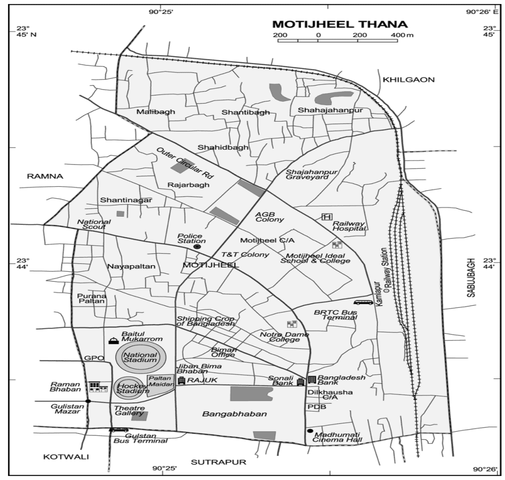

Figure 2: Motijheel Thana

2.2 Emission Inventory Analysis

There is no reliable emission inventory available for different emission sources in Dhaka city from government sector. The Department of Environment (DOE) has done some roadside emission inventory tests under CASE project but they have not come up with individual emission factors of each pollutant in terms of mass per km travelled. There was an initiative ongoing at DOE to generate an emission inventory for the whole country but didnt come to light . As such we had to depend on international literatures to calculate emissions. The emission factors used in this paperwork is taken from Wadud & Khan, 2011 which is represented in Table 2. They used it from Urbanemission, 2009 which focused on South Asian countries with some modifications. They also corrected the emission factors to include the impact of the super-emitting vehicles using Bond et al., 2004.

Table 2: Emission Factors (Source: Wadud & Khan 2011)

Vehicle type	Fuel	Emission Factors (gm/km)					
		PM_{10}	**CO_2**	**CH_4**	**SO_2**	**BC**	**OC**
Motor Car	Petrol	0.13	258	0.14	0.07	0.04	0.04
	CNG	0.05	237	2.53	0	0.01	0.03
SUV/Station wagons	Petrol	0.14	331	0.14	0.07	0.03	0.03
	Diesel	1.27	332.5	014	0.3	0.72	0.23
	CNG-Diesel	-	363	2.53	0	0.01	0.03
	Petrol-Diesel	-	304	2.53	0	0.01	0.03
Taxi	CNG	0.05	237	2.53	0	0.01	0.03
Bus	Diesel	2.37	887	0.06	1	1.35	0.43
	CNG	0.2	968	8.49	0	0.005	0.013
Minibus	Diesel	2.24	665	0.06	1	1.28	0.4
	CNG	0.15	726	8.49	0	0.01	0.03
Truck	Diesel	2.82	887	0.06	1	1.6	0.51
Auto rickshaw	CNG	0.1	75	1.41	0	0.02	0.07
Motor cycle	Petrol	0.1	40	0.08	0.02	0.03	0.03
Others	Petrol	0.14	331	0.14	0.07	0.03	0.03
	Diesel	1.27	332.5	0.14	0.3	0.72	0.23

2.3 Mathematical Modelling of Emission Calculation

A single emission factor is used to represent a particular type of vehicle and general type of driving. Emission is estimated using the equation:

E (p, k, m, t) = y (p, k, m, t) * v (p, k, m, t) * VKT (k, m, t)...(1) (Labib et al, 2013)

Where,
E = emissions of pollutant (p), for vehicle class (k) and fuel type (m) during time interval (t)
y = emission factor for pollutant (p), for vehicle class (k) and fuel type (m) during time interval (t)
v = volume of vehicle class (k) differentiated by fuel type (m) at specific time interval (t), and
VKT = Vehicle kilometer travel by vehicle class (k) for fuel type (m) at time interval (t).

2.4 Percentage Shares of Fuel Types

The Department of Environment Bangladesh has undertaken a Clean Air Sustainable Project (CASE) which has inspected emissions of in-use vehicles in major cities of Bangladesh viz., Dhaka, Chittagong Cox's Bazar, Rajshahi, Khulna, Jessore, and Kustia. The project team tested emissions of 1140 vehicles in different cities during the period from March 2011 to July 2012. In Dhaka they have tested 760 vehicles operated by petrol, diesel and CNG. The data collected is summarized by them only for Dhaka City (Table 3) as the number of vehicles tested in other cities is not very high. As the vehicles were inspected randomly, the fuel wise distribution of the vehicle population in Dhaka may be assumed in the same proportions.

Table 3: Fuel Share (Source: CASE 2012)

Vehicle type	Total number tested	Fuel wise vehicle number tested			% Vehicle as per Fuel used		
		CNG	Petrol	Diesel	CNG	Petrol	Diesel
Auto rickshaw	116	112	4	-	97	3	0
Car/Taxis	113	108	5	-	96	4	0
Jeep/Micro-buses/Station wagons	58	47	2	9	81	3	16
Delivery van/Mini Truck	188	83	2	103	44	1	55
Minibus/Bus	92	56	-	36	61	-	39

More than 96 % cars and three wheelers and 81% jeeps/microbus presently use CNG due to its lower price than petrol. CNG fuelled commercial vehicles like delivery vans and small size goods carriers/mini- trucks, accounted for 44% and the CNG fuelled minibuses and buses numbered 61%, the balance being diesel operated.

3. DATA COLLECTION

All the data used in this paperwork are primary data collected by the authors. Traffic volume data were collected by using smart phone video camera. Footages were captured from 8 and 10 different links of Dhanmondi and Motijheel Thana respectively. According to the manual of traffic count, the counted volume should be representative of the average traffic flow on a particular section of road. We used traffic volume expansion factors of rural roads which have more or less free flow all the time. The links of Dhaka city is very different form rural roads. So care was taken so that the stations are not placed at a point of the links where abnormal traffic flow occurs. Normally intersections have more congestions than the midways of the links. In this study, all the video footages were captured at the midway of the links where traffic flows are homogenous. Public holidays, school holidays, strikes or any other days when the traffic flow could be unusual from regular days were strictly avoided. As the video had to cover the whole roads of way from both directions, video was captured at an elevated place. The duration of each video was 30 minutes. The places chosen as stations are:

- Over bridges
- Elevated stories of roadside markets
- Roofs of residential buildings.

Traffic volume data collected from the video footages and shown in Table 4 does not represent the total number of motorized vehicles plying on the road. It includes both single as well as repeated trips generated within the study areas throughout the year.

Table 4: Traffic Volume Data of 2015 (in Thousands) (Source: Field survey by authors)

	Vehicle Type	Motor Car	SUV/Station Wagon	Auto rickshaw	Motorcycle	Minibus	Bus	Truck	Minitruck	Others
Dhanmondi Thana	Elephant Road	11103	4685	4034	4115	2485	285	20	448	529
	Mirpur Road	15112	4487	4301	3819	2503	778	148	222	185
	Kataban, Bir Uttam CR Dutta Road	4894	1280	4066	3049	18	18	18	376	150
	Panthapath Road	9392	1926	3652	3411	160	40	20	240	361
	Green Road	3619	1832	3887	3083	22	22	22	357	714
	Dhanmondi 2	5750	1097	3518	1967	851	170	75	226	756
	Sat Masjid Road	8659	1893	4475	2719	602	137	17	619	1273
	Dhanmondi 16	9571	2065	2788	2375	17	17	17	17	550
Motijheel Thana	Outer Circular Road	1531	765	1480	1250	434	178	25	51	25
	DIT Avenue Road	3501	1743	1443	2315	142	57	28	128	1715
	Nazrul Islam Road	3630	1572	2515	1886	1343	314	28	343	114
	Toyenbee Circular Road	4442	1386	2263	2405	877	2037	169	877	282
	VIP Road	9004	2744	8461	3916	57	57	85	743	57
	Shamsul Alam Road	3253	1839	1726	1782	481	226	70	198	254
	Khilgaon Road	6711	1813	3854	3763	68	45	22	498	1405
	Shantinagar	4187	1834	1131	1980	28	28	28	113	198
	Motijheel Road	2372	1229	514	1400	2458	1515	100	114	28
	Bangabandhu Avenue Road	2772	1000	1715	1943	929	1400	71	314	314

4. CALCULATIONS AND DATA ANALYSIS

This section will be dealing with the calculation and analysis of the collected data which includes estimation of total annual vehicular emission, energy footprint, physical footprint, transport footprint and bio-capacity.

4.1 Estimation of Vehicular Emission:

The six global emission parameters were calculated using the aforementioned emission model. The traffic data were collected in the year 2015. So the vehicular emission inventory represents the emission pattern of the year 2015. Emission factors of Methane (CH_4) were not available in Urbanemissions. They were collected form Reynolds and Kandlikar (2008). Dispersion of pollutants within the area is not considered in this study which can cause a slight variation in the outcome. The amount of pollutants are expressed in metric tons (1000kg). Table 5 represents the total annual vehicular emission within Dhanmondi and Motijheel area of the 2015.

Table 5: Calculation of Vehicular emission (Year 2015)

Area	Total Annual CO_2 (tons)	Total Annual PM_{10} (tons)	Total Annual SO_2 (tons)	Total Annual CH_4 (tons)	Total Annual BC (tons)	Total Annual OC (tons)
Dhanmondi	67743.9	70.3	18.1	475.1	31.5	17.9
Motijheel	82426.7	47.1	10.6	800.7	17.2	11.5

4.2 Estimation of Transport Footprint

The total transport footprint is the function of the total energy footprint and the physical footprint of the road network system. It is the sum of these two factors. This is the measure of the total area required to ease the intensity of pollutants below tolerance limit.

Total Transport Footprint = Total Energy Footprint + Total Physical Footprint..(2)

4.3 Estimation of Energy Footprint

Energy footprint is the function of Annual Average Daily Traffic (AADT), emission factors, link-wise vehicular activity and CO_2 sequestration factor. The AADT is also a function of 24 hour traffic volume and hourly, daily and monthly expansion factor. The expansion factors used is basically for rural primary road but it can be used in this study as the volume is counted at the midway of every link which represents nearly homogenous traffic flow. Vehicular activity of a link is considered to be the length of the entire link. It is expressed in terms of km per day. Now to determine the total biologically productive area needed for consuming this emission a CO_2 Sequestration Factor is used. It is 1.6175 for per acre of land (Ewing et al 2010) and then it is converted to local hectare by multiplying the resulting value by 0.4047 (U.S. Department of Energy and Information Administration, 2011).

Total Energy Footprint = Total CO_2 emitted (tons per year) /CO_2Sequestration (tons CO2/acre/year) * Hectares conversion factor..(3)

4.3.1 Estimation of Physical Footprint

The total physical footprint of a road network is determined by calculating the total road area. DAP report indicates that about 8% of total land of Dhaka city is dedicated for road network (DAP, 2004). As we have considered some selected major links for emission inventory, the physical footprint of this study will indicate the roadway area of those links only. The width of each link was measured from google map. Then a wighted average width was calculated by multiplying each link width to its length and dividing by the total length of all the links considered within the study area. In this way, the average roadway width was found out to be 14.5 m and 17.5 m for Dhanmondi and Motijheel thana respectively. The total length of the considered links were 11.7 km and 13 km. So, the total physical footprint of the both areas are 0.17 km^2 (17 hectares) and 0.23 km^2 (23 hectares). The calculation of determining transport footprint using equation 2 and equation 3 is represented in Table 6.

Table 6: Calculation of Transport Footprint

Area	Total Annual CO_2 (tons)	Sequestration (tons/acre/year)	Conversion Factor to hectares	Total Energy Footprint (hectar)	Global hectare conversion factor	Total Physical Footprint (hectar)	Global hectare conversion factor	Total Transport Footprint (gha)
Dhanmondi	67743.9	1.6175	0.4047	16949.6	1.26	17	2.51	21399
Motijheel	82426.7			20623.2		23		26042

4.4 Estimation of Bio-capacity

Biocapacity is an aggregated measure of the amount of land available, weighted by the productivity of that land. It represents the ability of the biosphere to produce crops, livestock (pasture), timber products (forest), and fish, as well as to uptake carbon dioxide in forests. It also includes how much of this regenerative capacity is occupied by infrastructure (built-up land). A country's biocapacity for any land use type is calculated as

BC= A* YF* EQF...(4) (Ewing et al 2010)

where BC is the biocapacity, A is the area available for a given land use type, and YF and EQF are the yield factor and equivalence factor, respectively, for the country land use type in question. The yield factor is the ratio of national to world average yields. The National Footprint Accounts include six main land use types: cropland, grazing land, fishing ground, forests for timber and fuelwood, forests for carbon dioxide uptake, and built-up land. It is estimated that 21.57% of the total area of Dhaka city is dedicated to bioproductive areas among which agricultural land is 12.12%, garden 0.9%, graveyard 0.036%, lake 0.15%, vacant space 5%, park 0.9%, playground 0.39%, pond 0.25%, swamp 1.82%, urban forest 0.02% etc. (Uddin M.N, 2006). But the open spaces available for Dhanmondi and Motijheel have different pattern from the whole Dhaka city. The agricultural lands (croplands) which comprises the largest portion of bio-capacity is absent in these two areas. For this study fishing ground, forest and built up areas are considered as bioproductive area. The fishing grounds and forest lands were measured from google map. Ponds and lakes are considered as fishing grounds while parks, gardens and any other lagre gathering of trees are considered as forestlands. It was found that, for Dhanmondi area the fishing ground and forest lands are 3.91% and 5.65% of total land use and for Motijheel the percentages are 0.94% and 3.74% respectively. From satellite image analysis it was found that for the year 2009 the built up area was 36.91% of the total land use for Dhaka city. All the yield factors and equivalent global hectares conversion factors which are collected from Ewing et al, 2010. Table 7 contains the calculations of determining bio-capacity.

Table 7: Calculation Transport Footprint-Bio-capacity Ratio

Land use	**Area (hectares)**		**Yield Factor**	**Global hectare conversion factor**	**Bio-capacity (gha)**		**Total transport footprint/ Total bio-capacity**	
	Dhanmondi (hectare)	**Motijheel (hectare)**			**Dhanmondi**	**Motijheel**	**Dhanmondi**	**Motijheel**
Forestland	26.82	17.52	0.351	1.26	11.86	7.75	25	31
Fishing ground	18.53	4.42	1	0.37	6.86	1.64		
Built-up land	174.95	173.11	1.852	2.51	813.26	804.71		
Total					832	814		

5. RESULTS AND DISCUSSION

This portion will be dealing with the comparison of estimated Transport footprint and bio capacity, comparison of modal shares and comparison of each vehicular emission parameters between Dhanmondi and Motijheel Thana.

5.1 Comparison of Transport Footprint and Bio-capacity

It has been found from Table 6 that the total transport footprint of Dhanmondi and Motijheel Thana is 21,399 and 26,042 global hectares respectively. It means they must have these amounts of biologically productive areas available to attenuate the intensity of CO_2. But Table 7 indicates that the bio-capacity of these two areas is only 832 and 814 global hectares. This means that the transport footprint of Dhanmondi and Motijheel area exceeds its bio-capacity by 25 times and 31 times respectively. This is the result of rapid urbanization which demands more infrastructures and less open areas to maximize the economical output of a city. Although both situations are way out of tolerable limit, still it can be said that a commercial area is more vulnerable to air pollution than a residential area. During the estimation of bio-capacity it was found that Motijheel has no major forestland or fishing grounds. Bangabandhu National Stadium and Maulana Bhashani Hockey Stadium comprise main portion of bioproductive areas of Motijheel Thana which are not sufficient in comparison with the huge amount of pollutants emerging daily within the area. The reason behind Dhanmondi having a lesser transport footprint-bio capacity ratio is the Dhanmondi Lake and it surrounding park which alone cover almost 62% of the total bioproductive area available within the area. But this is also not enough to reduce the extremity of pollution coming out from vehicles.

5.2 Comparison of Modal Share

From the analysis of the captured video footages it has been found that Dhanmondi Thana has a greater share of Motor car, SUV/Station Wagon, Auto rickshaw and Motorcycle. On the other hand Motijheel has a greater share of Bus, Minibus and other large vehicles. This is basically because of the landuse pattern of the respective areas. Dhanmondi is a residential area and most of the trips generated within this area are home based trips such as work, school, shopping, social, recreation and other personal purposes. Most of the people living in this area are economically well off and prefer Motor car or SUV/Station wagon for these sorts of activities. Similarly, Motijheel is a commercial area and most of trips generated within this area are non-home based and particularly work based. There are lots of banks and other commercial offices in Motijheel. Most of the people working in these offices prefer to commute by using public transport as their daily mode of transportation due to economical reasons. People who have their personal Motor cars also prefer public transport most of the time due to parking problems and safety issues. That’s why Motijheel has a larger share of Bus and Minibus.

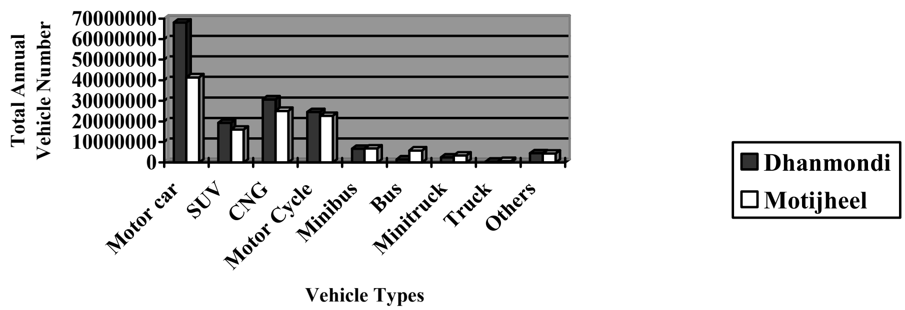

Figure 3: Comparison of modal share

5.3 Comparison of Vehicular Emission Parameters

From Figure 4 it can be seen that the total annual vehicular emission for CO_2 and CH_4 are greater in Motijheel Thana. For the rest of the other emission parameters (SO_2, PM_{10}, BC and OC) the annual vehicular emission is greater in Dhanmondi Thana. The reason can be easily understood if we go through Table 2. It indicates that the emission factor of CO_2 and CH_4 are largest for Bus, Minibus and Trucks and from Figure 3 we can see that Motijheel has a greater number of these larger vehicles which make it more polluted in terms of CO_2 and CH_4. For the rest of the pollutants, CNG driven large vehicles (Bus, Truck) have smaller emission factor than CNG driven small vehicles (Motor car, SUV). Figure 3 depicts that Dhanmondi has a greater share of Motor car, SUV, Auto rickshaw and Motorcycle which make it more polluted in terms of those pollutants.

6. RECOMMENDATION

The huge amount of emerging pollutants from vehicle exhaust have become one of the greatest concerns of Dhaka city. The biologically productive areas are not sufficient enough to absorb the ever increasing traffic pollutions. There is hardly any scope left to develop any bio productive area in Dhanmondi and Motijheel Thana. One of the widely discussed options for domestic CO_2 offsets is tree planting. Not only it offsets CO_2 but also it facilitates the human respiratory system. The two terms are generally used for tree plantation; reforestation and afforestation. Reforestation is planting trees in a place that used to be a forestland and has recently been cleared through timber harvesting or natural disaster. Tree planting has greater carbon sequestration potential than other land use practices. Afforestation of crop or pasture land is estimated to have the potential to sequester between 2.2 and 9.5 metric tons of CO2 per acre per year. Reforestation is estimated to have the potential to sequester between 1.1 to 7.7 metric tons of CO2 per acre per year. American Forests is a non-profit organization which has come out with a method to calculate the carbon sequestration of a single tree which helps to determine the number of trees required for an area to relieve the intensity of CO_2.

The first step in determining how much carbon is sequestered by a single tree is to convert carbon to carbon dioxide (CO_2) or carbon dioxide equivalent (CO_2e). The common conversion is; 1 ton of carbon = 3.666 tons of CO_2. This represents the weight of carbon dioxide (44) divided by the atomic mass of carbon (12).

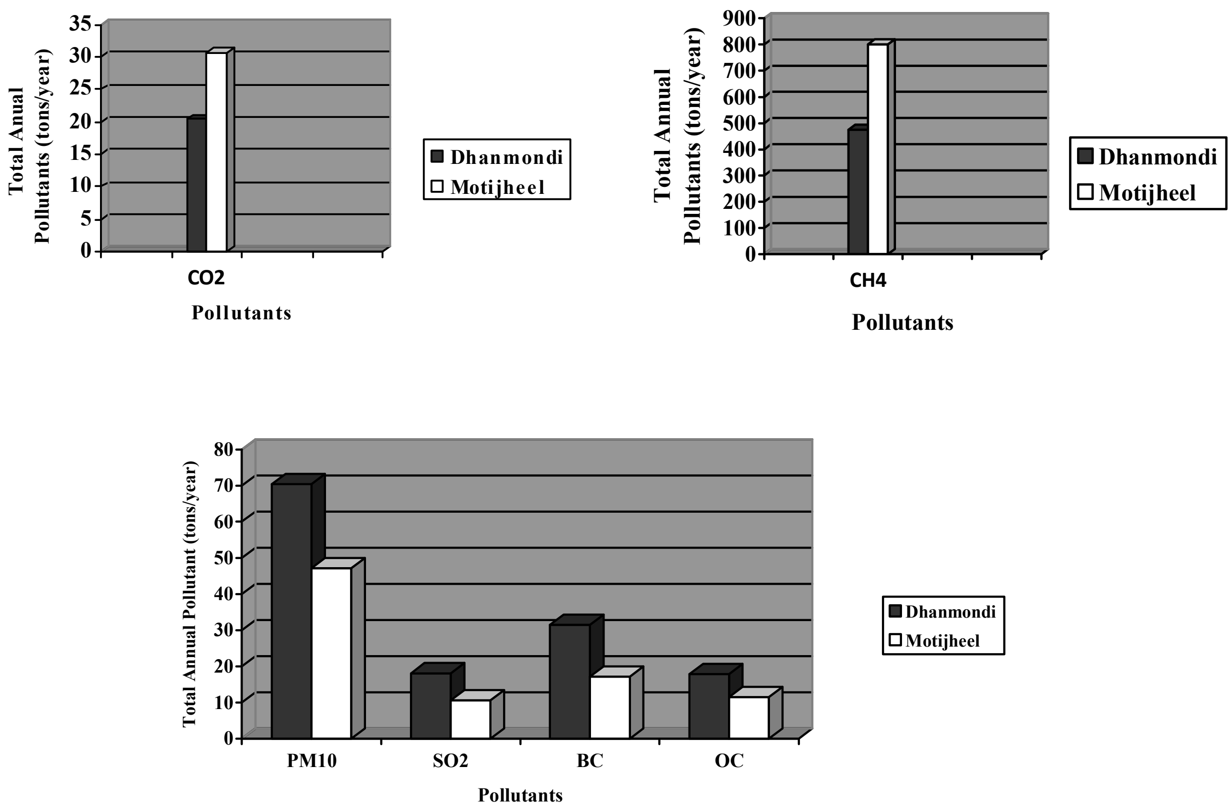

Figure 4: Comparison of Annual vehicular emission

Next, it is estimated that one acre of trees can store 50.8 metric tons of carbon which is equivalent to 186 metric tons (410,060 lb) of CO_2 per acre of forest. American Forests has estimated that a tree planting project averages 450 trees per acre, which leaves us with one final calculation; 186 metric tons of CO_2÷450 trees per acre = 0.4133 metric tons or 911 pounds of CO_2. This means an individual tree can take up 0.4133 metric tons or of CO_2. From this study it is found that Dhanmondi and Motijheel Thana produce 67743.9 and 82426.7 metric tons of CO_2 respectively in the year 2015. According to the above calculation it can be said that Dhanmondi and Motijheel requires almost 1,64,000 and 2,00,000 trees to be planted respectively in the year 2015. It is quite impossible to plant this huge amount of trees within such small areas. But knowing the number of trees required will help the policy makers to make decisions on this regard.

Some of the other recomendations may include improvement of non-motorized transportations, car share or carpolling, rescheduling of office or school timing, transit oriented development, innovation of low carbon transport, regular check-up and maintenance of new vehicles and also strict restriction to ply old vehicles.

8 and 10 major links have been considered in this study. However there are many minor links which have not been taken into considerations. The traffic pattern of minor links are very different from major ones. So the pollutions of minor links can't be estimated as a percentage of major links without proper traffic volume survey. There were restrictions of time and resources in our study. So the contribution of minor links to the total emission of these two areas are not included in this study. Further survey in the minor links could be done to evaluate their impacts on the total emission.

Emission of vehicles during idling condition has not been accessed in this study due to insufficient data and lack of scope to conduct laboratory tests. Also emission dispersion modelling has not been accessed here. Addition of these two parameters can enhance the reliability of the emission inventory analysis.

7. CONCLUSION

Dhaka city is gradually turning into an unsuitable place for living because of the huge amount of air pollutants producing at an alarming rate. The city is not capable of receiving and consuming this enormous amount of air pollution with its small area. The major finding of this study is that the transport footprint exceeds the bio-capacity by 25 times and 31 times for Dhanmondi and Motijheel Thana respectively. This indicates that a commercial area has more deficiency of bio-capacity than a residential area due to its land use pattern. This study also calculates the total amount of annual emission of six global emission parameters (CO_2, PM_{10}, CH_4, SO_2, BC and OC) which gives an idea about the current situation of vehicular pollutions of these two areas as well as of the whole Dhaka city. The modal share pattern of these two areas are also analyzed in this study which reveals that private vehicles like motor car and SUV/station wagon dominate the roadway of Dhanmondi Thana while public transports like minibus and bus dominates the roadway of Motijheel Thana. Accordingly, different restrictive traffic management measures need to be undertaken to control emission level for the study areas.

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