VEHICULAR EMISSION INVENTORY OF PAKISTAN

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Introduction

The rapid urbanization in Pakistan has resulted in a terrific increase in the number of motor vehicles. Current traffic scenario is causing multiple issues for its inhabitants. Transportation is a major source of global pollutants and contributing 21% in greenhouse gases worldwide (Gorham 2002). Transportation contributes 37.1 million tons CO2 equivalent in 2008 and if it follows the same pattern emissions will be 66.6 million tons CO2 equivalent in 2020 (Ministry P&D, UNDP). This research will be carried out to quantify the pollution linked to vehicles for Pakistan. The main pollutants under study are Nitrogen oxides (NOx), Sulfur Dioxide (SO_2) and Particulate Matter (PM_{10}). Data will be used from 2001-2013 of motor vehicles registered and on-road vehicles. It estimates the air pollutant emissions from different types of vehicles and fuel used.

STUDY AREA :

This study is performed in three levels first level comprise of entire country, next level consist of provinces individually. A comparison of major cities is also done to get a clear picture of transport scenario which constitutes level 3. The cities are Islamabad, Rawalpindi, Lahore, Multan, Faisalabad, Peshawar and Karachi.

A total domestic load of 239 billion passenger kilometers and 153 billion ton kilometers is generated annually. Total road network of Pakistan is 263,775 km, out of which 70% are paved and road density is 0.32 km/km^2 (Economic survey, 2008). The increasing trend of vehicles of Pakistan is shown in ***Figure 1***, while in ***Figure 2*** the share of each province in vehicular population is shown.

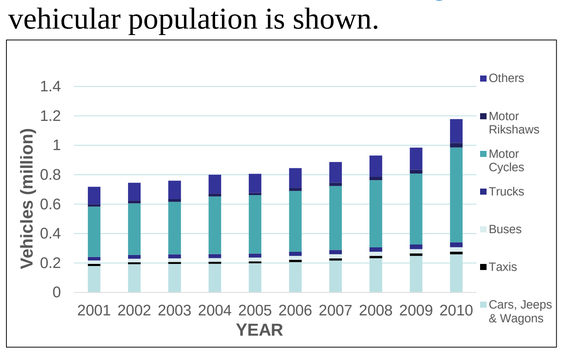

Figure 1: Vehicles Trend of Pakistan

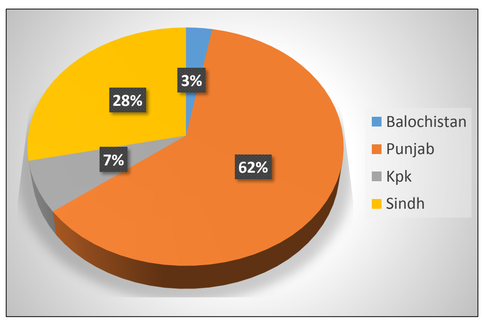

Figure 2: Provincial share in vehicles of Pakistan 2010

Methodology

Emission inventory of major pollutants $S0_2$, NOx, and PM_{10} was developed by using following factors:

- Number of Vehicles
- Diminishing factor of vehicles
- Vehicle Kilometer traveled (VKT)
- Fuel efficiency
- Emission factors
- Load factor

The emissions can be calculated as follows:

$$Ej(t) = Vi\ (t) * DV * VKTi(t) * EFij(t) * Fi * Li$$

Ej(t) is the total emission in tones of emission type j in year t, Vi is the total number of certain vehicle type in year t, DV is the diminishing factor of vehicles, VKTi(t) is the average annual distance traveled in kilometers by a vehicle type i in year t, Efij(t) is the emission factor of pollutant j of vehicle type I, Fi is the fuel efficiency of vehicle type I in km/l and Li is the load factor for vehicle type i.

Data regarding number of vehicles was gathered from Pakistan bureau of Statistics and National Transport Research Station, emission factors, fuel efficiency and load factor were estimated from published literature, for VKT a survey was conducted in different cities, using the surveys and existing knowledge VKT was estimated. Diminishing factor for vehicles taken was 15%. Emission factors used for the inventory is given ***Table 1***.

VEHICLES	Fuel Type	Emission Factors(g/km)		
		NOx	SO_2	PM_{10}
Car, jeeps & wagons	Gasoline	2.81	0.02	0.06
	Diesel	1.13	1.95	0.46
	CNG	1.4	0.01	0.01
Taxi	Gasoline	1.17	0.01	0.05
	Diesel	0.89	1.67	0.26
	CNG	0.1	0.01	0
Motorcycles	Gasoline	0.54	0	0.06
Rickshaws	Gasoline	5.4	0.01	0.18
Bus	Diesel	5.4	0.01	0.18
Trucks	Diesel	12.96	5.58	1.25
Others	Gasoline	3.89	0.01	1.25

Table 1:Emission Factors of main criteria pollutants in g/km

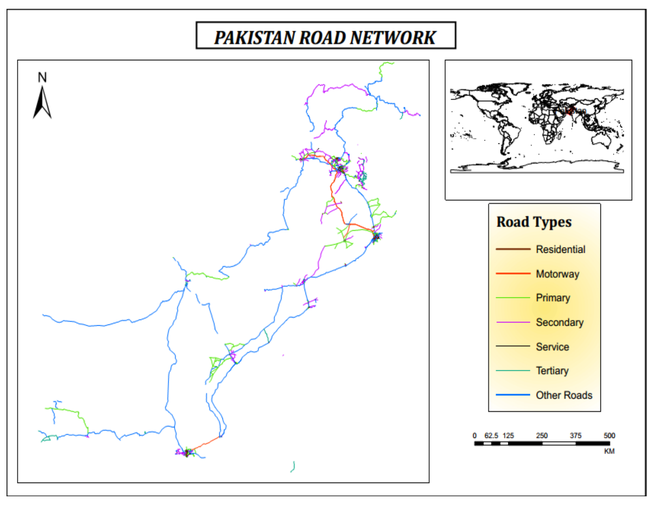

Figure 3: The road network of Pakistan. This map contains main roads of country that connect many cities and provinces.

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Results

Due to increase in number of vehicles the emissions are also increasing in environment of Pakistan. The criteria pollutants NOx, SO_2 and PM_{10} exhibits a great increase in last years as seen in ***Table 2***. In year 2001, NOx was 121767 million tons in Pakistan and rise up to 625789.1 million tons in 2011. NOx exhibits a total of 67% increase in these 10 years. Similar trend was seen in PM_{10} emission, a total of 67% increase from year 2000 to 2001, PM_{10} emitted in 2001 was 4233.926 million tons, and in 2011, it increased up to 21293.55 million tons. While SO_2 shows 47% increase in this time period, in 2001 SO_2 was 1700.59 million tons and increased to 4749.33 million tons in 2011.These results are shown in ***Figure 3*** .

EMISSIONS(million tons)			
PAKISTAN			
YEARS	NOx	SO_2	PM_{10}
2001	121767	1700.196	4233.926
2002	128303.3	1924.031	4478.519
2003	132704.3	1968.343	4629.291
2004	157551.3	2052.214	5461.875
2005	162351.7	2062.856	5620.613
2006	175920.4	2276.88	6096.523
2007	193952	2510.252	6721.45
2008	213033.3	2885.891	7401.483
2009	238057.8	3292.836	8280.738
2010	415126.7	3919.271	14217.33
2011	625789.1	4749.334	21293.55

Table 3: Year wise emissions of pollutants in Pakistan

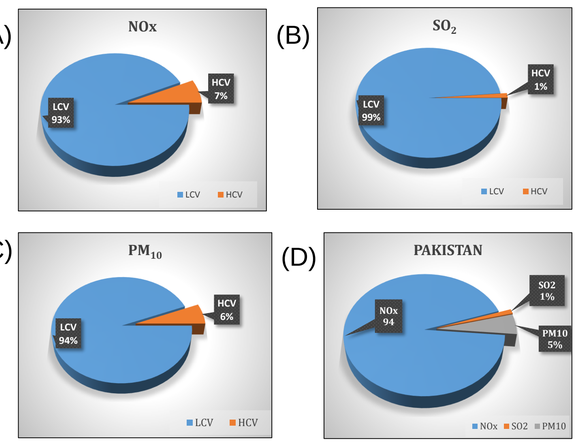

Figure 3: (A) Share of light commercial vehicles (LCV) and Heavy commercial vehicles (HCV) in NOx .(B) Share of LCV and HCV in SO2. (C) Share of LCV and HCV in PM10. (D) Percent contribution of main criteria pollutants NOx , SO2 and PM10 in total emission of Pakistan.

In all provinces NOx contribution is highest than SO_2 and PM_{10} , SO_2 was 1% except in KPK where it is 3% due to less NOx and the reason behind this is mainly it's topography, cars and motorcycles are in lesser number there as compare to Punjab and Sindh, which reduces the overall ratio of contribution of pollutants. While PM_{10} share ranges between 2-4%.

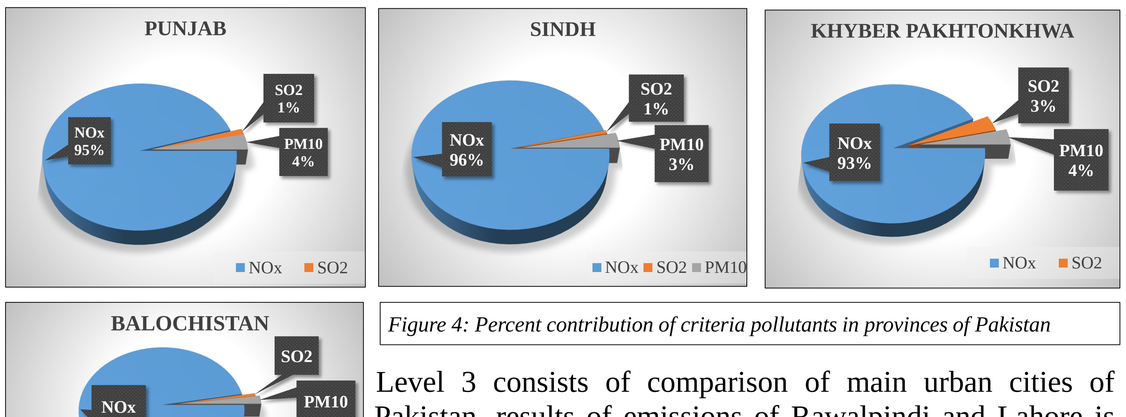

Figure 4: Percent contribution of criteria pollutants in provinces of Pakistan

Level 3 consists of comparison of main urban cities of Pakistan, results of emissions of Rawalpindi and Lahore is given below. For the cities of Karachi and Peshawar, due to unavailability of data, one year data is taken. The emission of NOx was 155.78 million tons, SO_2 was 19.57 million tons and PM_{10} was 8.12 million tons in Peshawar in year of 2009. In Karachi, the emissions of year 2012 was NOx at 594.65 million tons, SO2 at 7.57 million tons and PM10 at 46.19 million tons.

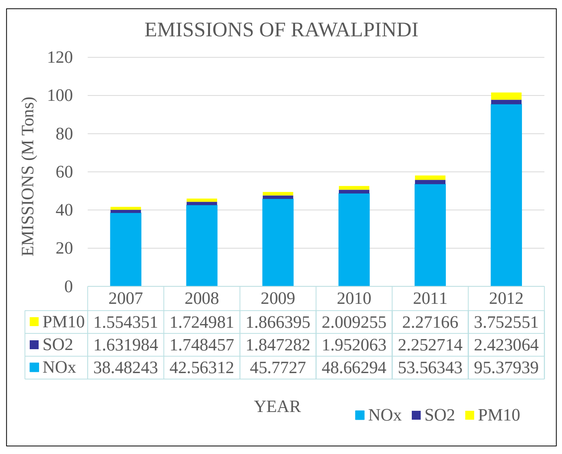

Figure 5: Emission trend of pollutants in Rawalpindi

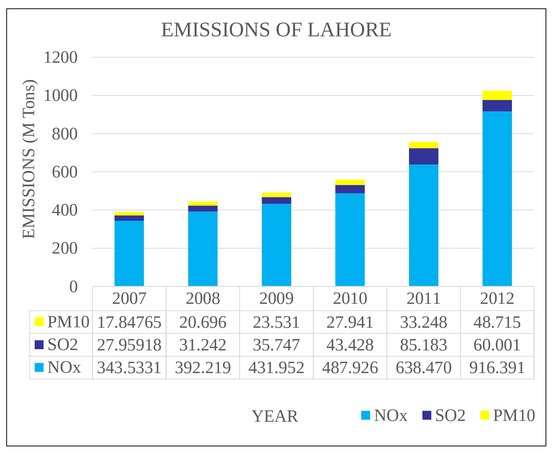

Figure 6: Emission trend of pollutants in Lahore

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