Air Quality in Urban areas in Pakistan Vs Transport Planning: Issues and Management tools

By

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Abstract: ***Transport and energy sectors are considered to be the major air polluters. Road transport sector causes more urban airborne pollution than any other single human activity. Improved technology alone has not been able to outweigh the amount of pollution emitted by shear increased number of cars in addition to share of old technology cars on the road in the developing countries like Pakistan. Transport and energy sector contributes nearly one half of the NO_x, two-thirds of CO, and about one half of hydrocarbon emissions in the industrialized countries. Urban air quality can be improved by integrating a number of technical and management options and financial incentives including better traffic flow and transport management / planning in the urban areas (which has not been given due importance until now in Pakistan), change of technology including fuel substitution & conversion to less polluted fuels (e.g. low Sulphur / Lead fuels, CNG), and using management tools for effective implementation of laws linking control on emissions and fuel adulteration, strengthening vehicle inspection and maintenance and transport planning. The present talk will be helpful in briefing about the existing air quality in urban centers of Pakistan, current activities for controlling this menace, their impact on urban air quality and future suggestion to include transport management for reduction of urban air pollution in the context of a developing country like Pakistan***.

Introduction: Air pollution is an emerging environmental issue in major cities of Asia. Societies / Governments from developing countries have failed to recognize the limitations of the cleansing capabilities of the atmosphere. Rapid growth of infrastructure in cities, together with associated growth in road transport systems, has made the region increasingly concerned for these emissions. Air Quality impacts include direct health problems to the life forms (e.g. humans, animals, fish etc), vegetation and forest growths, damage to soils, climate change impacts including changing the regular patterns of seasons, rains, floods, draughts, desertification, deforestation, global warming, Oxygen and other gas blanket affects global warming, Ozone layer depletion, Acid Rain effect, material and building damage associated with high levels of oxides and has resulted in depletion of the scarce natural resources needed for long-term sustainability of ecosystem etc [2].

Direct and indirect cost-benefit analyses of environmental problems are difficult to evaluate and needs prioritization and judgment. With limited resources to address environmental degradation and its associated impacts, attempt to establish clear priorities requires assessment of environmental quality and losses in monetary units. Analysis conducted so far [3] indicates that environmental costs are high and indirect. A recent World Bank report estimated 3% of GDP cost for estimation of Lead & SPM related economic cost in Malaysia [24]. It has been pointed out that Urban Air pollution causes average annual damages to the economy in the range of US $ 369

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[3] EPRC Project : "**Setting Environmental Priorities: Valuing the Environment**", Draft Report by M. W. Addison, Dec 31, 1996 and The World Bank Report by Dr. Brandon 1992-3

million [3] and is ranked as the second most important contributor after Municipal solid and liquid wastes. These losses to national exchequer are colossal when compared to the costs of pollution abatement. Failures in incorporation of these factors in economic policies contribute to significant loss to Pakistan's GDP and create many health/environmental problems.

The seriousness of the atmospheric pollution for urban communities had led to the introduction of **National Pollution Control (NPC**) Policies in the developed countries in mid 70's and implementation of **NAAQS (National Ambient Air Quality Standards) / IAQS (Indoor Air Quality Standards) for domestic and industrial application.** These NPC, NAAQS and IAQS were basically aimed at tackling local pollution problems without considering trans-national transport of pollutants. Given that pollution control is itself costly and long-term gains cannot be achieved, since developing countries lack the technical & financial resources to address this issue. It is necessary for the individual country to decide how much of their limited resources should be allocated for pollution control. We believe that **pollution control and prevention are not desirable luxuries but necessary parts of sustainability and survival of the ecosystem**. Air **pollution control strategy**, a **master plan to control / prevent air pollution problems**, was introduced with the help of Male Declaration amongst countries of South Asia since end of 1998.

Air Quality Management (AQM) designates the level of pollution established in terms of **outdoor / indoor ambient air quality standards** and controlling pollutant emissions from fixed and mobile sources to ensure that these limits are not exceeded. De Nevers et al [4] has defined AQM as "**regulation of the amount, location, and time of pollutant emissions to achieve some clearly defined set of ambient air quality standards or goals**". Obviously an approach involving regulating emissions from millions of stationary & mobile pollution sources with varying characteristics, location and use patterns are not simple. Unfortunately efforts in developing countries, like Pakistan, to improve air quality could not identify transport sector, its planning and management as an important parameter. Asian Development Bank has recently given due importance to this issue and is involved in flow of knowledge from developed nations towards developing countries and it will bring dividends on the application of these suggestions within the next decade or so.

Pakistan Scenario : Statistics for Vehicular Data : Pakistan has been struggling to implement its PEPA 1997, which does not include standards for clean outdoor / indoor air (NAAQS/ IAQS) and vehicular emissions and their associated parameters as yet. Some important statistics for Pakistan are as follows:-

[4] De Nevers, N.H., Neligan, R. E. and Slater, H. H. 1977:- Air Quality Management, Pollution Control Strategies, Modeling, Evaluation, A. C. Stern (ed.) ***Air Pollution, vol 5: Air Quality Management,*** New York: Academic , 3-40

Table 1 : - Important Air Quality parameter information [5].

Country / City	Population Million	Vehicular population	Importance for air quality
Pakistan	140	4.3 million	Road infrastructure 250,000 Km [6] [23], Transport, industry (brick kilns, thermal power plants & steel), municipal solid wastes, climate, Forest / green cover.
Karachi	9.3	Over 0.7 million	Largest industrial / transport / residential sector, Forest / green cover.
Lahore	5.13	562,000 vehicles & ~ 3000 SME / industries	Large industrial / transport / residential sector, climate
Rawalpindi / Islamabad	1.9	125,000 vehicles and 600 medium sized industries 276,000 [7] in Rwp district	Medium sized industrial / transport / residential sector. Population growth rate is 3-4 times than average growth of other cities.
Peshawar	1.0	160,000 vehicles [7]	Climatic / soil conditions, Brick kilns, Forest / green cover.
Quetta	0.56	70,000 vehicles [7]	No rain for the past few years: soil & climate, Forest / green cover.
Hyderabad	1.15	100,000 vehicles [7]	Steel, surgical / cutlery & ceramic sectors are concentrated
Multan	1.18	175,000 vehicles [7]	Petroleum refinery, chemical, leather tanning & associated sectors, fertilizers & thermal power plants: soil & climate, Forest / green cover.

A comparison of rise in transport sector was obtained from National Transport Research Cell (NTRC: www.moc.gov.pk/ntrc & www.ntrc.com.pk) and is provided in the next table 2. Pakistan consumes 17 Million Ton of petroleum products, with 7.8 Million Tons for transport sector only (~ 20% Petrol & 80 % Diesel), with an annual growth of about 6% [8]. Pakistan has to spend US$ 2.5 billion a year on import of crude oil and deficit petroleum products [9]. Quality of fuel used has a strong bearing on urban air quality issue, since traditionally reports of adulteration were observed.

[5] Pakistan Statistical Year Book 1998-9 by Federal Bureau of Statistics, Government of Pakistan Nov 1999
[6] Country Study : Pakistan by Yasin Tahir, SJS, MOIP, in regional consultative meeting on "Promotion of Intra-regional trade & Economic Cooperation …." Seoul, Republic of Korea, 102 December 2001.

[7] National Transport Research Center (NTRC) source: private communications
[8] Introduction of Clean Fuels in Pak by Rashid Farooq, DG Oil, Ministry of Petroleum & Natural Resources, GOP.
[9] "Liquid Fuel substitution policies in Pakistan", by Hilal A Raza, International Symp. on Development Policies for the new Millennium 12-4 July 2000 in Indira Gandhi Institute of Development Research, Mumbai, India.

Table 3 shows the quality of fuel used currently and table 4 expresses the quantity of fuel oil used in the last few years with annual consumption growth at 6.72 %. HDIP [25] classified vehicles into 2 types i.e. Petrol 4 wheeler of population as 955,000 with ACGR of 6.3% and diesel buses / trucks population as 253,000 with ACGR of 6.8%.

Table 2 : Transport data rise (Source National Transport Research Center) [7]

Class of Vehicle	Petrol / Diesel /CNG / LPG	1980	2000	Rise %
Delivery Vans (Suzuki Vans)	D / P	8503	109722	1190
Motor cycles	P	287622	2113078	634
Cars TAXIS CARS	P/D/CNG/LPG P/D/CNG/	148334	748,909	405
Trucks	D	34193	158645	364
Buses	D	25275	91910	264
Rickshaws	P	31950	93300	192
Total / others	Mix P/D	682059	4293836	530

Table 3: Quality of Fuel oil currently in use in Pakistan and comparison with other countries of the region (Source Pakistan Energy Year Book 1998) [5 & 8]

Fuel Type	Pakistan	Other Regional Countries
Lead in Gasoline	From 0.42 to 0.35 gm/liter	Unleaded - 0.15 gm/liter
Sulphur in Diesel Oil	1 %	0.05 – 0.5 %
Sulphur in Furnace oil	1-3.5 % by weight	0.5 – 1 %

Table 4: Fuel Consumption (Source Pakistan Energy Year Book 1998) [5 & 8]

Year	1990-1	1992-3	1993-4	1994-5	1995-6	1996-7	1997-8	1998-9	2000-1
Fuel x MTOE	7.8	12.3	13.5	14.2	15.8	15.8	16.8	17.0	19.35 [25]

Table 4a: Sectoral oil Consumption [25] 2000-1: Total 19.35 Million Tons

Sector	% age
Transport	46.2
Power	36.8
Industry	10.9
Domestic	2.6
Other Govt.	2.1
Agriculture	1.4

Current Air Pollution Scenario in Pakistani Cities : Transport and energy sector contributes nearly one half of the NO_x, two-thirds of CO, and about one half of hydrocarbon emissions in the industrialized countries [10]. Rapid urbanization coupled with increase in population and associated transport and other provisions, unplanned growth and increase in industrial sector have resulted in increase of air pollution problems in big cities of Pakistan as observed in other thickly populated mega cities of the region. The major constituents of urban air pollution consist of Total SPM, PM_{10}, $PM_{2.5}$, Lead particulates, SO_2, CO, O_3, NO, NO_2, non-methane hydrocarbons, and THC levels higher than normal

Recent surveys carried out in the country using mobile units (for example one carried out with the assistance of JICA and Pak EPA) revealed presence of very high levels of suspended particulate matter (SPM [12]) in major cities (about 6 times higher than the World Health Organization's guidelines) and NOx levels. In Lahore, Rawalpindi and Karachi levels of Carbon monoxide, oxides of Nitrogen and Sulphur dioxide were also found in high concentration in other studies. Most of these measuring campaigns have been conducted using mobile units for short duration. Research has already proved direct relationship of respiratory diseases with level of SPM / PM_{10} / $PM_{2.5}$ and other gases in the ambient air. Dust allergy, throat irritation and cough are very common in Pakistan. Direct affects of air pollution on health, climate change, vegetation, rainfall patterns and ecosystem is established. This situation warrants continuous monitoring of ambient air quality through fixed monitoring stations to establish baseline data, identify sources, understand the impacts and adopt remedial measures to minimize these impacts as had been experienced in other mega-cities of Europe, USA and Asia. It is believed that SPM / PM_{10} / $PM_{2.5}$ are generated mainly due to vehicular (2 stroke & diesel engines) and natural sources while oxides of C, N & S from transport and industrial sectors involved in burning of petroleum products on large scale.

Data on concentration profile of these important pollutants in ambient urban environment is scarce especially in the developing countries like Pakistan due to infrequent monitoring. Limited sporadic data collected in Pakistan from mobile units on these pollutant levels in urban ambient air indicates that concentrations above acceptable levels for human health have already been reached in certain urban areas with high traffic volume / levels, and in the vicinity of heavy industries such as steel mills, brick kilns. Samples taken from streets of Karachi even in 1971 showed CO levels in the range of 3 to 35 ppm. CO increased from 1 - 10 ppm to 30 ppm in Lahore from 1974 to 1984 [11]. NO_x levels observed in 1994 for various cities of Punjab already show higher levels than suggested

[10] TORs for the project on Air pollution Monitoring issued by ENERCON, part of project on Fuel Efficiency in Road Transport Sector (FERTS), 1998

[11] Background Information for Paper on ***"Environmental Issues in the Energy Sector in Pakistan"*** by Hagler Bailly Pakistan, 1997.

by NEQS. A recent study by JICA [12] suggests industrial emissions in Lahore include carcinogens like asbestos and soot, SPM / PM_{10} / $PM_{2.5}$, and noxious gases into the air without any treatment causing air quality to decline and increase respiratory diseases. Typical air pollution emissions examples in Islamabad are of SO_2 from Sulphuric acid plants, NH_3 from fertilizer units and H_2S from gas purification operations are reported to exceed safe limits [12]. Similarly Lahore is facing deteriorating ambient air quality problems linked with heavy industrial activity and emissions without treatment or control. Residents in the vicinity of Industrial Estates in Islamabad are facing serious air pollution problems and associated health issues [13]. A study reported that around 3000 industrial units in Lahore emit 4406 tons of PM, 285 tons of CO, 1000 tons of HC, 162 tons of NO_x and 50 tons of SO_2 in 1979-80 [14]. JICA identified [12] industries as the principal contributor to SPM / PM_{10} / $PM_{2.5}$ emissions representing 68% of total air emissions in Lahore. The contribution of all other industrial emissions, including CO, SO_2, HC, NO_x are below 5% as mentioned in the same report. In addition, Lahore is also facing an extended winter fog lasting for 2-3 weeks observed in the past few years causing huge economic loss, health problems like respiratory and cardiovascular diseases. This was attributed to burning of coal in India and increased combustion of dirty fuels [15]. A survey conducted by Punjab EPD measured PM 4.35-9.8 mg/nm^3, Lead 1.16 µg/m^3 and Co 4.4 ppm [16]. In another report, CO levels measured at various locations of Lahore were found to be well above the threshold limit of 35 ppm set by USEPA [17]. Another study by Punjab EPD [18] measured various parameters in Lahore and Rawalpindi and results are presented in the next table 5. The results of JICA are presented in Table 6 for reference. The results obtained show that NO_2, PM_{10} and TSP are the key parameters exceeding the international standards. Heavy metals in ambient air are shown in table 8. Average values for Arsenic and Lead were observed to exceed the international standards in most places. Similarly another report by DHV consultants indicated that SPM, NOx, and Lead as serious problems exceeding WHO guidelines by more than a factor of two for Karachi [19].

Table 5 : Air Pollution in Lahore and Rawalpindi region in 1998-99 [18]

Cities	Ambient Air Quality Parameters (hourly Maximum Concentrations)			
	CO ppm	0_3 ppb	SO_2 ppb	NO_x ppb
Lahore	8 - 9.2		50 - 80	300 - 450
Rawalpindi	1.2 – 6.2	27 - 62	4.5 - 27	25 - 250
Rawat Village	0.8	31	2	< 20
Measurement Methodology	IR Gas filter correlation	UV Photometry	UV Fluorescence	Chemilumi-nescence

[12] ***"Investigation of Air & Water quality in Lahore, Rawalpindi & Islamabad"***, March 2000, by JICA & Pak EPA
[13] ***"Environmental Survey of Industrial Estate"***, Islamabad, report prepared by Hagler Bailly Pak.for SDPI 1999.
[14] ***"A Study on Air Pollution in Lahore",*** by M.N. Tariq, H. Shaukat and W. Waheed, Institute of Public Health Engineering and Research, UET Lahore, 1983
[15] ***"The Sources of Widespread Winter Fog in Northern Pakistan and India***", by R Sultan Hameed et al., 1998-99
[16] ***"Annual Progress Report of EPA Research Laboratories",*** K.B. Nasir, M. Khalil, and Farah Adeeb, 1993-94
[17] ***"Automotive Air Pollution- Issues and Options for Developing Countries', Policy, Research and External Affairs,*** Asif, K. Sinha and Amiy Varma, 1990.
[18] ***"Study on Ambient Air Quality in Lahore and Rawalpindi",*** Pun EPD, 1998-99.
[19] ***"Ambient Air Monitoring needs***", by DHV consultants BV, Netherlands Consortium for The World Bank Rep 202, EPA Sindh, 1997

Table 6 : Air Pollution range in Lahore, Islamabad and Rawalpindi region in 1999-2000 [12]

City / site	Ambient Air Quality Parameters (1 hour average)					
	CO ppm	NO_x ppm	SO_2 ppb	0_3 ppb	PM_{10} µg/m^3	TSP µg/m^3
Standards	35 USEPA, WHO, EU	110 - NO_2 0.053 ppm annual arithmetic mean USEPA 0.04-0.06 1 hr mean for a day Japan	134 WHO 130 (3 hr Av. µg/m^3 USEPA 500: 3 hr average USEPA 100 : 1 hr	90 WHO 120 USEPA 80: 8 hr average. 60 1 hr	200 Japan 150:24-hr average USEPA	200 Japan
Lahore :- site 1	0.5 - 7	32-194 NO 99–357 NO_2	19-88	2.8-12.9	578-1362	3045
Site 2	0.1 – 9.4	7.4-331.5 NO 46.8–405 NO_2	8.9 – 72.4	1.7 – 17	109.5 - 1349	2120
Site 3	0.6 – 4.2	8.6 - 25 NO 52 – 96 NO_2	0 - 211	1.6 – 43.9	373 - 1324	2210
Site 4	0.7 – 6.8	4 - 296 NO 24 - 423 NO_2	2.8 – 95.1	0.4 – 110.6	68.4 - 1400	1975
Site 5	0.1 – 9.4	2.7-499 NO 33–556 NO_2	9.6 – 95.2	0.1 – 48.5	90.6 - 1535	2230
Rawalpindi : site 1	0.3 – 2.8	3.5 - 57 NO 19 - 110 NO_2	0 – 7.8	7.1 – 59.3	372 - 1166	675 - 1171
Site 2	0.3 – 6.7	46– 207 NO 39 – 237 NO_2	10 – 46.7	0.7 – 52.6	40-1214	1371 - 2744
Site 3	0.5 – 3.6	11 - 263 NO 24 – 95 NO_2	12.2 - 61	0.5 – 54.9	513.7 – 1406.3	3724
Islamabad - site 1	0.1 – 3.0	53 - 355 NO 103–349 NO_2	17.1 – 60.2	0.0 – 48.4	107.9 – 937.8	2385
	0.8 – 3.6	10 –191 NO 30 – 239 NO_2	4.3 – 47.3	0.1 – 52.5	80.7 – 853.6	2230

Table 7 : Air Pollution (PM) range in Major cities from various studies carried out between 1993-98 (source EPD/SUPARCO/NWFP EPA)

Cities / sites	PM µg/m^3
International Standards	**120 WHO Guidelines** **200 Japan**
Multan	1030
Lahore	895
Faisalabad	870
Peshawar	834
Rawalpindi	709
Islamabad	520
Karachi	230

Table 8: Heavy metals in ambient air samples [12]

Cities / sites	Arsenic µg/m^3	Copper µg/m^3	Lead µg/m^3	Zinc µg/m^3
International Standards	**0.32 Arizona State** **0.01 ppm Japan**		**0.5-1.0 WHO** **1.5 USEPA** **2.0 EU**	
Lahore	0.25 – 2.23	0.52 – 6.72	0.9 – 7.85	0.92 – 5.82
Rawalpindi-Islamabad	0.19 – 3.12	0.53 – 8.33	0.71 – 10.93	1.08 – 4.48

Male Declaration on Control and Prevention of Air Pollution and its likely trans-boundary Effects for South Asia, March 2000, Phase I reported the following comparison (table 9) amongst the country of the south Asian region mentioning vehicular emission as major source of air pollution and table 10 shows the present situation of various environmental laws for AAQS.

Thus efforts are required to:-

- Collect baseline continuous ambient airborne pollution indicator data / levels in the country,
- Develop linkages between pollutant concentration Vs source identification & their contribution / quantification,
- Incorporate atmospheric dispersion models in pollution dispersion / dilution and
- Initiate pollution index levels being monitored / dissipated with weather reports,
- Implement certain feasible mitigating measures to reduce these levels,

- Assess the efficiency of these measures in reducing these pollution levels and
- Reduce the emissions of these pollutants through improvement programs in Pakistan.

Adoption of national guidelines / standards for air quality, consistency in laws and strong enforcement will be able to provide the required results. Policy instruments can range from simple command and control instruments to communication tools.

Emissions from energy use in Pakistan in 1998 for CO_2 emissions were 96, SO_2 1.11 and NO_x 0.54 million tons [9].

Two stroke engine vehicles constitute nearly half of the total vehicles population in South Asian cities, contribute significantly to urban air pollution in terms of noise, fine particulates SPM, PM_{10} & $PM_{2.5}$, unburnt HC, Lead, etc. Incorporating vehicle age, maintenance, lubricant and fuel quality, two stroke engines are polluter in order of magnitude than 4 stroke engines of same size. Two stroke engines have typically lower fuel efficiency than 4-stroke engine.

Very little and inconclusive information is available on contribution of vehicular emissions with respect to current air quality in the cities.

Table 9 : Ambient air Pollution comparison amongst countries of South Asia:- A summary

Country	Nature of Air problems	Status	Pollutants monitored	No. of Monitoring Stations	Capacity of MS	AQ standards notified	SO_2 Concentration or total emissions	NO_2 Concentration $\mu g/m^3$ or total emissions
Bangladesh	Vehicular Coal burning, Industrial	No systematic monitoring: Random monitoring	SPM, SO_2, NO_x, CO, Pb	4	Limited	Env. Conservation Rule 1997 covering column 4	Dhaka City, 1998, 95-150 $\mu g/m^3$	
Bhutan	Vehicular, Industrial, Forest fires	As above	SPM, SO_2, NO_x, CO,	3	none	no		
India	Industrial, Power Vehicular,	Systematic for few industries / cities	SPM, RSPM, SO_2, NO_x, CO, Pb, PAH, H_2S, NH_3	280	CPCP, NEERI	AAQS 1981 for RSPM, SO_2, NO_x, CO, Pb,	3-4 million ton / yr from 1991-97	5.5 – 8.2 million ton / yr from 1991-97
Iran	Vehicular, Industrial	No systematic monitoring: Random monitoring in Tehran only	SO_2, NO_x, CO, O_3, TSP	15 stationary 23 portable	limited	1995 order of ICA	0.3 – 0.75 million ton S / yr from 1980-98	0.3 – 0.95 million ton S / yr from 1980-97
Maldives	Urban, Tran boundary over ocean	No Monitoring data from INDOEX [20]	No	No	No	No	No	No

[20] Indian Ocean Experiment (INDOEX) conducted by an international group of Scientists

Nepal	Vehicular, Industrial, Fossil fuel, rural	No systematic monitoring: Random monitoring	TSP, PM_{10}, SO_2, NO_x, CO, Pb	No continuous monitoring	Limited	No standards for stationery sources, Vehicles emission standards introduced	~15000-20000 ton S / yr from 1992-96	24000 – 36000 ton S / yr from 1992-97
Pakistan	Vehicular, Industrial, Power plants, Biomass, waste	No systematic monitoring: Random monitoring	PM_{10}, SO_2, NO_x, CO, metal	3 portable	Limited	NEQS for industries, AAQS for thermal power plants	0.3 – 1.0 m ton / y	-
Sri Lanka	Vehicular, Power	No systematic monitoring: Random monitoring	PM_{10}, SO_2, NO_x, CO, O_3,	2 fixed in CMR, 5 mobile	Limited	CEA standards for column 4	25000 – 40000 tones / y	82,000 – 118,000 tones equ/y
Egypt [16]	Vehicular traffic, industries	Partial systematic monitoring for few area and pollutants	SO_2, NO_x, CO, O_3, HC, SPM, heavy metals	6 mobile units for measuring AAQ	Limited	Notified 1994, 1982	100 – 260 mg/m^3	90-200 mg/m^3

[16] JICA-Pak EPA, # 3, Review of Pak Environmental Air Quality and Emission Standards Promulgated, May 2, 2001, My Y Shigeta (JICA Env Expert stationed at Pak)

Table 10 : Comparison on law for Ambient Air Pollution :- A summary [21]

Pollutant	SPM (µg/m^3)				SO_2 Units: ppm (µg/m^3)			NO_2 Units: ppm (µg/m^3)				CO Units: ppm (µg/m^3)			O_3 ppm (µg/m^3)	
Name of country / Standard	**1 hr**	**8 hr**	**24 hrs**	**1 yr**	**1 hr**	**24 hrs**	**1 yr**	**1 hr**	**24 hrs**	**1 yr**	**Notes**	**1 hr**	**8 hrs**	**24 hrs**	**1 hr**	**8 hrs**
Pakistan Unpolluted Highly Polluted	-	-	-	-	 - -	 - -	 (50) (10)	-	-	0.05 (100)		-	-	-	-	-
USA 10 µm	-	150	50	-	-	0.13, (365)	-	-	-	0.053		35 (40000)	10 (11000)	-	0.12 (235)	-
Japan 10 µm	200	-	100	-	0.1	0.04	-	-	0.04-0.06	-		-	20	10	0.06 (120)	-
Saudi Arabia 15 µm	-	-	340	80	0.28 (730)	0.14 (365)	0.03 (80)	0.35 (660)	-	0.05 (100)		35 (40000)	9 (10000)	-	0.15 (195)	
Mexico 10 µm TSP	- -	- -	150 275	- -	-	0.13	-	0.21 (395)	-	-		-	13	-	0.11	
Chile TSP	-	-	260	80	-	0.14	0.03	0.25	0.16	-		35	9	-	0.12 (235)	

[21] JICA-Pak EPA, # 3, Review of Pak Environmental Air Quality and Emission Standards Promulgated, May 2, 2001, My Y Shigeta (JICA Env Expert stationed at Pak)

Netherlands 10 µm	-	-	150	-	(200) 6 months	(100)	(50)	0.06 (110)	0.04 (75)	0.025 (50)	Sweden winter				0.12 (235) Netherland	
UAE 10 µm	300	-	150	-	0.13	-	0.03	0.15	-	0.06		20 (22860)	-	-	0.08 (157)	
Kuwait 10 µm	-	-	350	90	0.17	0.06	0.03	0.1	-	0.5		35 (40000)	8 (9140)	-	0.08 (157)	
WHO Recommended Level	50	-	120	-	(350)	0.048 (125)	0.02 (50)	0.21 (400)	0.08 (150)	0.02 (40)		35 (40000)	9 (10000)	-	0.09 (180)	(0.11)

Sources of Air Pollution: With the current technical and financial resources available in Pakistan, it is very difficult to quantify the individual share of the contribution of the existing air pollution in the cities. Following can be associated as the major sources of urban air pollution levels:-

1. **Vehicular emissions**; As explained above, vehicular emissions are treated as one of the important source for total emissions by a number of countries (e.g. Male document) but its contribution has not been quantifiable as yet. Total emissions by transport sector in 1998 was estimated in National Emissions Inventory of Pakistan for Male Declaration on Control and Prevention of Air Pollution & its likely Transboundary Effects for South Asia by Hagler Bailly Pakistan in May 2000 and is briefed as 324,473 tons of NO_x (over 90 % by diesel as source of fuel & 9.5 % by Gasoline: 65 % share of total NO_x emissions by all sectors), 35,362 tons of PM (93% by diesel driven vehicles & 6.5 % by Gasoline: 2 wheelers, motor cars & tractors are dominant sources; 6 % share of total emissions), 120,871 tons of SO_2 (99 % diesel driven vehicles: 16 % of total SO_2 emissions). Emission factors were estimated with slight inaccuracies since quality of roads, vehicle age / maintenance & fuels are important parameters which are ignored.

2. **SME in and around cities**; Small and medium industries located within and around cities are also important in the assessment of air quality issues. Industry in Pakistan is concentrated geographically e.g. leather tanneries are concentrated in Kasur, Sialkot & Multan region, cutlery in Wazirabad, textile in Faisalabad and Lahore, light engineering and electrical goods in Gujraat and Gujranwala, sports and surgical in Sialkot, Steel in Karachi & Lahore, petroleum refining, thermal power plants & Fertilizer industry in Multan etc. In addition brick kilns are diversified all over the country especially in the suburbs of cities.

3. **Industry & power sector***:* Major users of diesel and furnace oil are power plants, which in turn produces SPM, NO_x & SO_2 in addition to other parameters.

4. **Municipal Solid waste management system**; Terminology like **WRAP (Waste Reduction Always Pay)** and **NIMBY (Not In My Back Yard)** are quite effective in educating the society for the necessity of properly designed ***Integrated Municipal Solid Waste Management (***IMSWM) system for cities. Presently there is no city in Pakistan with properly planned and efficient IMSWM system incorporating the acceptable standard of environmental protection and health. Proper and appropriate methods of dumping are not employed. In most of the cities solid waste especially plastic bags get into open drains and sewers choking the system. Owing to the low levels of financial, technical, development and economic consideration, it is not possible for civic / public agencies (like municipalities, development authorities) to make use of latest techniques, technologies and equipment being used in developed world. Municipal bodies lack resources to remove the entire solid waste resulting in poor sanitary conditions especially in low-income areas, thereby contributing to air pollution scenario. This results in creating health hazards to public including air pollution & water contamination increase in rodent, insects and bacteria.

Existing mitigation measures: Pakistan is working on policies incorporation on cut down its import bills for petroleum products and improve the environmental scenario. In this regard

following programs are in the process with limited or partial impacts due to a variety of constraints. Brief information is supplied for each of these programs:-

1. **FERTS tune up activities**[23]; Fuel Efficiency in Road Transport Sector (FERTs) project of ENERCON, Ministry of Environment (www.ferts.8k.com) , is working on the tune up facilities in various cities of Pakistan and is tuning 28000 gasoline vehicles so far in the last 2 years from 15 tune up facilities, thereby improving air pollution and petrol consumption. Their work indicated that 94% of vehicles being tuned are older than 7 6 years and only 6% is lesser than 1995. Details of their work and assessments are attached as annexure in Excel format file. An overall 54% reduction of CO, 462 Tons of CO_2 and 15% efficiency in fuel consumption is being claimed by ENERCON so far. This reduction can be attributed because of improved engine working and fuel saved because of consumption improvement. The project will result in savings of US $ 19.8 million per annum to vehicle owners due to better efficiency and will result in annual reductions in emissions of CO_2 (262,040 tons), SO_2 (1478 tons), lead (7 tons), Hydrocarbons (5659 tons), CO (67343 tons) and SPM (5342 tons) estimated by Pak-EPA in the report on Male Declaration. A loan of US $ 3 Million is being negotiated for expansions to 200 tune up stations planned in the next 2-3 years.
2. **VETS by GTZ**: Vehicle Testing Station (VETS) has tested over 18000 (Petrol & Diesel) vehicles and based on their data average reduction in smoke emissions from diesel is reported as 28% in terms of opacity and 77% in CO in samples of randomly selected vehicles [22] [23]. Possible reduction in PM_{10} emissions from diesel vehicles ranges 160 Tons/year and CO from petrol vehicles 913 tons/year [22].
3. **Fuel substitution & clean up** [8] [9] [24]; Ministry of Petroleum and Natural Resources (www.mpnr.gov.pk), Government of Pakistan, has been working on the reduction / elimination of Lead in Petrol, reduction of Sulphur in HSD & Fuel oil with recommended targets of 1997 Clean Fuel Workshop like a) reduction of Lead from 0.84 to 0.42 to 0.35 mg/litre (completed) and introduction of unleaded petrol in selected cities by the end of 1997, b) reduction of Sulphur in HSD from 1.0 % by weight to 0.5 % and in fuel oil from 3.5 to 2 % by the end 2000, c) reduction of Lead in leaded Gasoline throughout Pakistan from 0.35 to a maximum 0.15 mg/litre by the end of 2003 d) Complete phase out of Lead in Gasoline throughout Pakistan, e) introduction of catalytic converters for all new cars and restrictions on import of vehicles without catalytic converter, f) restriction on 2 stroke engine technology for fitting catalytic converters (rickshaw, motor cycles etc) and finally g) price of unleaded and leaded petrol to be same for control on adulteration. This objective will be addressed by modification of configuration of existing oil refineries, setting up of new refineries with latest technology & import of low Sulphur HSD & Fuel Oil. Estimated additional cost on import / introduction of low Sulphur HSD & Fuel oil will be in the range of US $ 300 million per year.

[22] Air Pollution in Peshawar & Impacts of Vehicle Emission Testing Station by GTZ Pak German Urban Industrial Environment Protection Program April 2000.
[23] Private communication with ENERCON, Iftikhar A Raja And Arif Alauddin
[24] Report on status of Implementation of Action Plan to achieve Clean Fuel Supply in Pakistan, by standing Committee on Clean Fuels, GOP & Report of the Committee on Clean Fuels: Pak Env protection Council

Committee on Clean Fuels [24] also recommended catalytic converters to be fitted on all two-Stroke engines and all public / private vehicles to testing and meeting of standards.

Shift towards gas driven processes in industries (especially Power plants, transport sector using Gasoline & heavy burning industries) will improve the environment and budgetary import constraints for Pakistan on Gasoline.

4. **Conversion to CNG** [9] [25]; Hydro-Carbon Development Institute of Pakistan (HDIP; www.hdip.com.pk) has been main driving force in promoting CNG as alternate fuel for transport sector (only for Gasoline driven vehicles for the time being) due to financial restraints. Environmental considerations are a byproduct, since CNG is claimed to be more environment friendly for NOx emissions [23]. HDIP has claimed as of to date in the transport sector that a) 220 CNG stations are operational in the country which are providing conversion & filling facilities, b) 210,000 petrol driven vehicles (22% of 4 wheeler petrol driven vehicles) have been converted to CNG, c) estimated daily CNG consumption is 17 MMCFD as in year 2001, d) Replacing 142,000 (13%) Tons per year of petrol and e) reducing Greenhouse and other gas emissions from transport sector. Although this shift has caused serious capacity and financial issues relating to refinery operation for gasoline production. Following table 11 shows the changing trends in various cities of Pakistan.

Table 11 [25]: Conversion to CNG driven vehicles (estimated figures)

Cities	Karachi	Lahore	Rwp / Isl	Peshawar	Quetta	Hyderabad	Multan
No of Vehicles converted	43000	38,000	84,000	12,000	250	1,200	5,000

Fuel related air pollution abatement measures include vehicle inspection programs, better fuel formulation, availability of unleaded & low Sulphur fuels, and promotion / use of alternate fuels (CNG, LNG, LPG), shift to gas are cost effective and require cost sharing by individuals and need a time frame in view of fast growing magnitude of air pollution. These measures, if implemented with proposed levels, will reduce for CO_2 emissions by 3 million tons i.e. ~ 3% reduction [9]. In addition, shift to gas will also reduce Sulphur, Lead and SPM from road transport and power plants.

Limitations and Constraints: Quest for growth (in terms of industry, power generation & transportation) play a key role in the development process of a country but ultimately deteriorates surrounding environmental conditions. Cities have become major **" environmental hot spots**" that urgently require special attention for studies and proper environmental and transport planning /and traffic management for air pollution and wastes management, ecological

[25] CNG Sub-Sector by Hilal A Raza, DG, HDIP on 11th Jan 2002 A presentation to the Task Force on Integrated Energy Security Action Plan.

sustainability and pollution controls. Almost all the main cities of Pakistan are faced with this peculiar time bound traffic pollution problems due to a variety of reasons which include:-

a) Flaws & inconsistencies in the policies and pricing structure of Gasoline-Diesel-CNG i.e. diesel is the dirtiest fuel which should be incentive driven to convert to CNG alongwith infrastructure not gasoline,
b) Heavy conversion from gasoline to CNG causing wrong impacts on economy (refineries reducing both diesel & gasoline production, diesel demand forcing to import diesel),
c) Faulty and inappropriate tuned vehicles on the road not effective VIM (Vehicle Inspection & Maintenance); ineffective but identified introduction of legal, planning & institutional changes for annual motor vehicle testing and inspection system,
d) Use of inappropriate fuel mixtures, petroleum adulteration and available fuel mixtures with high Lead & Sulphur contents,
e) Lack of maintenance culture or no preventive maintenance concept in government, public & private vehicle fleet,
f) Prioritization of various options for transport sector like Railways, pipelines, roads, flyovers, by passes & mass transport,
g) No control / standards / tests are available on fuel / engine performance enhancing techniques / systems,
h) In the absence of an effective **urban mass transport system** in all the major cities, traffic problems are on the rise in these heavily populated cities thereby deteriorating air pollution concerns.

Traffic planning and flow management, which are important parameter for urban transport planning for reduction in fuel consumption, minimization of losses in work-hours and improvement in air quality, has not been linked by all sectors in order to reduce air quality as a primary component so far. In addition, speed limits on motorway and highways also reduce fuel consumption and increase emissions from vehicles at such speed limits. Motorway speed limits also be addressed for control on air pollution emissions. Conversion of two stroke engines, as suggested by the World Bank in a recent study, is also an important parameter, which cannot be addressed properly by the government policies. This workshop would be able to highlight its importance in these scenarios. Recent development in Pakistan on widening of roads / alternate routes and introduction of large fleet public urban transport system (working on CNG) availability in congested areas of Lahore, Rawalpindi and Karachi have been successful in reducing the pressures on certain routes.

Recommendations [8, 9]: Objective of all the above-mentioned projects can be achieved if :-

1. Vehicle inspection & examiner (VIM) department is strengthened by the provincial governments in consultation with Ministry of Transport / Communications, EPAs & ARUP to ensure standard condition / tuned vehicles on roads,
2. Quality control (PSQCA) agency with the help of MoP&NR and Provincial Governments on the quality of gasoline being sold by various stations & control on the sale of adulterated gasoline, diesel, CNG, LPG,

3. Establishment and implementation of Weigh Bridges by NHA & NH&MP with the help of ARUP on all important Highways & roads to check over-loading,
4. Policy / pricing structure be re-organized for conversion of dirtiest fuel (diesel) on road transport to clean fuel i.e. CNG instead of gasoline conversion to CNG, i.e. provision of disincentives against diesel driven vehicles,
5. Setting up of well equipped Petrol / Diesel / LPG / CNG Vehicles testing & tuning centers in all major cities & ripple effect of current activities by organization like ENERCON, VETS, NTRC & EPA,
6. Fuel substitution strategy can be improved if a) LPG supplies from domestic refineries be increased, b) find alternate import sources for LPG / natural gas through pipeline from neighboring countries,
7. Fuel substitution policy needs environmental initiatives for effective results, i.e. inter-se prices of HSD-MS Ron 87-CNG be rationalized, tax / duty incentives on CNG kits & equipments, CNG operated buses / trucks be exempted, lucrative bus routes for CNG, lower slab of road tax for CNG vehicles etc,
8. Undertake road shoulder improvement (concrete pavements or vegetation cover, traffic management like speed reduction & cleaning of road by vacuuming) by municipalities & traffic engineering bureaus for minimization of suspended SPM / PM,
9. Introduction of government subsidized **urban mass transport system** with large fleet using clean fuel would reduce the traffic burden from city roads / hot spots and as a result improve urban air quality in these cities.

Above all, give due importance on the transport planning and flow management in busy road sectors of various cities if at all, air quality be improved in addition to the existing programs being progressed.

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