3.3.1 INTRODUCTION

Air is indispensable for the survival of all living organisms on earth, including human beings. It is even more important than water - without water a person can survive for days, but without air no more than a couple of minutes.

Air pollution is one of a variety of manmade environmental disasters that are currently taking place all over the world. Air pollution may be defined as an atmospheric condition in which various substances are present at concentrations high enough above their normal ambient levels to produce a measurable effect on people, animals, vegetation, or materials. 'Substances' refers to any natural or manmade chemical elements or compounds capable of being airborne. These may exist in the atmosphere as gases, liquid drops, or solid particles. It includes any substance whether noxious or benign; however, the term 'measurable effect' generally restricts attention to those substances that cause undesirable effects.

Recently, air pollution has received priority among environmental issues in Asia, as well as in other parts of the world. Exposure to air pollution is the main environmental threat to human health in many towns and cities. Particulate emission is mainly responsible for increased death rate and respiratory problems for the urban population. This problem is acute in Dhaka being the capital of the country and also the hub of commercial activity. The other urban areas i.e. Chittagong, Khulna, Bogra and Rajshahi have much lesser health problem related to urban air pollution. The ambient atmospheric conditions have progressively deteriorated due to the unprecedented growth in numbers of motor vehicles, and continuous housing and industrial development.

Bangladesh is one of the least developed agrarian nations in the world. However, since it's birth in 1971, there has been some growth in the industrial sector. Industries are mainly concentrated in major urban areas like Dhaka (the capital), the seaport cities like Chittagong and Khulna, the inland port city Narayanganj, and other divisional towns. Naturally, the air pollution problem is more acute in these areas. Apart from unplanned industrial development in these areas, the severity of the pollution is increased mainly due to exhausts from two-stroke engine and diesel-run vehicles.

In the rural areas of Bangladesh, the air pollution problems have not yet become a point of concern. This is due to fewer motorized vehicles and industries in rural areas. The principal sources of emission in the rural areas are from brick kilns, and from cooking stoves. In rural areas, wood, coal, and bio-mass are used as sources of energy. Thus, it is likely that in rural areas the principal air contaminants are particulate matter and volatile organic compounds (VOCs). During the monsoon, rural people cook inside their houses without adequate ventilation systems. This give rise to severe indoor air pollution which adversely affects their health, particularly of women and children.

3.3.2 PRESSURES

Air quality has deteriorated both due to human activities, and natural phenomenon such as wind blown dust particles etc. There are two major sources of air pollution in Bangladesh, vehicular emissions and industrial emissions. However, these are mainly concentrated in the cities. Other than that there are numerous brick-making kilns used seasonally (in dry season) all over Bangladesh. Almost all of these kilns use coal and wood as their source of energy, resulting in the emission of particulate matter, oxides of sulfur, and volatile organic compounds. In addition to these usual sources of fuel, spent or used rubber wheels of vehicles are also burnt, which emit black carbon and toxic gases. These are hazardous for health. The emissions caused by these sorts of practices sometime exceed the mechanisms for the natural rate of purification of the local atmosphere giving rise to severe episodes of local air pollution.

Per capita energy consumption in Bangladesh is increasing with time, which affects the air quality indirectly. In Bangladesh from 1972 to 1980, per capita consumption of commercial energy increased from 24 to 32.8 kilogram oil equivalent (KOE). It grew to 41.3 KOE in 1985, and 56 KOE in 1989- 90. The total per capita energy consumption of Bangladesh in 1989-90 stood at 164 KOE, where commercial energy accounts for 34.6 per cent of the total energy used in the country. The rest is from non-commercial resources like agricultural waste, fuel wood, cow dung, etc. Table 3.3.1 depicts interlinks of pressures, states, impacts, and policy responses regarding air pollution. Detailed program responses are discussed in Section 3.3.5.

Table 3.3.1 Pressures, State, Impacts, and Responses to Air Pollution

Pressures	State	Impacts	Policy Responses
1. Urbanization	Increase in vehicle emission	Urban air quality deterioration	Bangladesh Environmental Conservation Act (ECA), 1995, and Environment Conservation Rules, (ECR), 1997
2. Industrial Pollution	Emission of SO_2, NO_x, Pax, Gases, Vapours	Air quality deterioration • Harmful for human health. • Plant quality and growth affected • Corroded building materials • Ecosystem disturbed	Bangladesh ECA '95 and ECR '97 More stringent enforcement of ECA and ECR enabled through capacity building of DOE
3. Emissions from Vehicles	PM, CO, NO_x, SO_2, VOC	• Human health hazard • Plant quality and growth affected • Corroded Building Materials • Ecosystem disturbed	Bangladesh ECA '95 and ECR '97
4. Brick fields and kilns	PM, CO, NO_x, SO_2	Health Hazard	The Brick Burning (control) Act, 1989 & The Brick Burning (control) Amendment Act 1992, Bangladesh ECA '95 and ECR '97
5. Building Construction	PM	Health Hazard	Bangladesh ECA '95 and ECR '97
6. Open dumping of Wastes for disposal	Gases, Vapour, Odors	Air quality deterioration	Bangladesh ECA '95 and ECR '97
7. Wood/Biomass/ Coal Consumption	PM, VOC, SOx	Health Hazard	
8. Fuel quality	VOC + others	Health Hazard	

Source: SoE Study Team

3.3.2.1 Rapid Urbanization

Urbanization is an inherent part of the process of economic development in Bangladesh, and its rate can be indicated by the large population growth in urban areas. In 1981 the total population in urban areas was 14.08 million, which increased to 22.45 million in 1991. With increased urbanization, the number of vehicles is also increasing rapidly, and contributing to more and more air pollution. The major urban centers in the country are the metropolitan cities of Dhaka, Rajshahi, Khulna and Chittagong. Dhaka, the capital of Bangladesh is one of the most densely populated cities in the world. This is the center for the major economic and commercial activities, too.

In the urban areas ambient air quality is dependent on many factors like air movement, traffic volume, congestion, emissions from motor vehicles, and resuspended dust particles. Various other activities related to the extremely high population density also result in severe air and other forms of pollution. The salient parameters of air pollution are suspended particles, sulfur oxides, nitrogen oxides, hydrocarbons, carbon monoxide, lead, ozone and other gases.

Aircrafts, railway engines, power plants, open-burning incineration, solid waste disposal sites, and dust particles also contribute to air pollution. Dust pollution due to road diggings, constructions and other development activities further aggravate the air pollution situation in cities. In order to accommodate the growing population, the construction of multi-storied buildings is increasing rapidly. Along with these buildings, the number of slums are also increasing. The tremendous pressure of population has made it almost impossible to maintain a clean environment in the capital city of Dhaka.

3.3.2.2 Emissions from Vehicles

Due to rapid and unplanned urbanization the total number of vehicles has increased enormously. Most of the cars, jeeps, auto-rickshaws, motorcycles, etc., ply in the cities. This has really led to a deterioration of air quality, particularly in Dhaka. Table 3.3.2 shows the different types of automotive vehicles plying in Dhaka, which indicates their rate of growth (BBS, 1997a).

Although the percentage of two stroke auto-rickshaws is around 8 per cent, some recent studies have shown that they contribute around 40 per cent of PM10 and 50 per cent of HC in Dhaka City. The second largest polluters are trucks and buses, although they constitute only 10 per cent of the total automotive vehicles in Dhaka. These cause about 44 per cent of the PM10 pollution.

The Department of Environment, and other concerned agencies and organizations, have identified the two-stroke engines used in auto-rickshaws, tempos, mini trucks, and motorcycles as major polluters. These vehicles with two-stroke engines have the worst emission levels of all types vehicles. As present, there are about 65,000 baby taxies among the more than 296,000 motor vehicles that ply in Dhaka city alone.

In a survey conducted by the Bangladesh Road Transport Authority (BRTA), it was found that the

Table 3.3.2 Types of Automotive Vehicles in Dhaka

Date	Car/Jeep/Stn. Wgn.	Scooter/M. Cycle	Autorickshaw	Tempo & Others	Buses	Goods Vehicles	Total
Apr-71	16,289	9,644	3,843	888	1,531	3,640	35,835
Apr-72	17,165	10,265	3,851	1,086	1,714	4,027	38,108
Apr-73	18,018	11,486	4,680	1,086	2,078	4,424	41,772
Apr-74	19,081	12,957	5,065	1,086	326	4,711	45,226
Apr-75	20,128	14,433	5,065	1,107	2,495	4,998	48,226
Apr-76	20,606	16,582	5,161	1,110	2,534	5,309	51,302
Apr-77	22,140	17,916	5,324	1,120	2,560	5,391	54,451
Apr-78	24,223	19,754	5,688	1,168	2,753	5,672	59,258
Apr-79	25,986	19,936	5,765	1,228	2,884	5,903	61,702
Apr-80	28,692	22,946	6,318	1,587	3,493	6,631	69,667
Apr-81	31,443	26,756	6,786	1,605	3,695	7,156	77,441
Apr-82	33,840	29,372	6,902	1,630	3,843	7,566	83,153
Apr-83	35,666	32,184	6,982	1,733	4,003	7,907	88,475
Apr-84	38,124	37,782	7,098	1,849	4,255	8,325	97,433
Apr-85	41,650	46,396	7,256	1,969	4,418	9,103	110,792
Apr-86	44,167	53,454	8,147	2,303	4,542	9,610	122,223
Apr-87	47,346	58,467	10,016	3,051	4,798	10,095	133,773
Apr-88	50,660	62,733	11,100	3,733	4,892	10,740	143,858
Apr-89	53,394	66,265	12,433	4,219	5,032	11,124	152,466
Apr-90	55,548	69,063	14,015	4,508	5,217	11,246	159,596
Apr-91	58,243	72,412	15,626	4,677	5,427	11,324	167,708
Apr-92	60,529	76,537	17,736	4,779	5,695	11,958	177,233
Apr-93	63,695	79,550	19,802	5,020	5,911	12,601	186,578
Apr-94	69,058	82,739	25,523	5,327	6,385	13,727	202,758
Apr-95	75,740	85,245	32,433	5,753	6,910	15,020	221,101
Apr-96	83,965	87,282	41,153	6,285	7,538	16,559	242,784
% in 1988	35%	44%	8%	3%	3%	7%	100%

Source: BBS, 1997a

Black smocks emitted from the vehicles does not bother road side food venders

two-stroke petrol engines are less fuel-efficient, and emit about 30-100 times more unburned hydrocarbons than four-stroke engines; and diesel engines emit 13 times more smoke than non-diesel four-stroke engines.

The automobiles on the roads are often very old, overloaded, and poorly maintained. Other old vehicles, including 40-year old trucks and dilapidated mini-buses, are also plying the city streets emitting smokes and gases. According to an assessment made by DoE, 90 per cent of the vehicles that ply Dhaka's streets daily are faulty, and emit smoke far exceeding the prescribed limit. Black smoke which is primarily unburned fine carbon particles is emitted by diesel vehicles. Table 3.3.3 indicates the low numbers of vehicles that are actually fit to be driven according to the Government standards for emissions versus the total numbers.

3.3.2.3 Unplanned Industrial Development

Industrial development is another source of air pollution. Industries in Bangladesh are situated mainly in major urban areas, particularly in Dhaka, Chittagong, and Khulna. Accordingly, air pollution is concentrated mainly in these cities. Table 3.3.4 indicates that the total number of manufacturing industries in Bangladesh increased about 11 per cent over the 4 years between 1988-1989 and 1991-1992 (BBS, 1997b). However, as the data includes only the recorded industries, the actual number of industries is expected to be much higher.

Textile and dyeing, tanneries, pulp and paper, cement, metal, fertilizer, and chemical factories in particular emit PM, sulfur oxides, nitrogen oxides, carbon monoxide, and ammonia, all of which deteriorate air quality. The geographical distribution of different industries is given in Table 3.2.2 in the Water Pollution and Scarcity section of the report.

Table 3.3.3 Good Quality Vehicles Numbers from 1981 - 1996

Year	Total vehicles number	Good vehicles number	Percentage of Good vehicles
1981	77,441	7156	9.2
1986	122,223	9610	7.8
1991	159,596	11,124	6.9
1996	242,784	16,559	6.8

Source: BRTA

Table 3.3.4 Growth in Industrialization for the period 1988-1992

Year	Number of Reporting Industries
1988-89	23,752
1989-90	25,283
1990-91	25,890
1991-92	26,446

Source: National Action Plan for Air Pollution, 1999

3.3.2.4 Brick Kilns

Brick-making kilns, of which the majority are of the conventional type, use coal and wood as their source of energy. This is mainly due to the non-availability of natural gas in most parts of Bangladesh. The air pollution from these kilns is not only due to the type of fuel used, but also due to the thermal inefficiencies of the conventional kilns. This causes emissions like SO_x, CO, particulate matters, and volatile organic compounds that deteriorate air quality. Another significant factor is that brick kilns are usually clustered near big cites in various parts of Bangladesh. Therefore, the parts of the city in the immediate vicinity of the clustered brick-fields have serious air pollution problems.

3.3.3 STATE OF AIR POLLUTION

A continuous monitoring scheme is essential to evaluate air quality and for the development of any

Air and water pollutions from unplanned industries

plan for mitigation of health risks caused by polluted air. The six "criteria pollutants", particulate matter (PM 10, PM 2.5), CO, SO_2, NO_x and ozone have to be monitored more or less continuously at a reasonably large number of locations. Other pollutants (e.g., ammonia, hydrocarbons, lead, carbon dioxide, etc.) should also be measured, where their levels are considered to be significant.

Again, the salient problems in the cities of Bangladesh are not like those in other developed countries. The developed countries are able to manage these problems, but in Bangladesh cost is a major criteria. There is also a general lack of expertise to evaluate the problems, or prepare cost-effective solutions, and therefore, the air quality is not yet managed effectively.

Monitoring of ambient air quality in Bangladesh is a very recent phenomenon, initiated on a very limited basis by DoE using high volume samplers, with the help of development partners. However, the acuteness of the problems caused by air pollution, and awareness campaigns organized by different mass media, have made the government aware of the necessity of monitoring ambient air quality. Accordingly, the Department of Environment has set up four monitoring stations at four divisional towns, namely, Dhaka, Chittagong, Khulna, and Bogra. Monitoring has been done mostly in Dhaka at various places, and samples collected analyzed for the three pollutants SPM, SO_2, and NO_x. Very limited monitoring has also been done at Chittagong for these three parameters. In addition to monitoring through these stations, the DoE conducts vehicular emission measurements in Dhaka cityoccasionally. In Dhaka City, the locations are: Tejgaon, Farmgate, Manik Mia Avenue, Gulshan, Lalmatia, and Agargaon. These areas represent industrial, commercial, and residential areas of the city.

In addition to DoE, a number of other organizations are monitoring air quality, as well as emissions from automobiles. The Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET) has been conducting ambient air quality surveys since 1995. The most recent one, conducted by the Department of Civil Engineering over a prolonged period in 1998, includes the measurement of SO_x and NO_x at 14 different locations of Dhaka city at different times of the day.

The air quality standards are different for residential, industrial, commercial, and sensitive areas. According to various studies the worst affected areas in Dhaka city include: Hatkhola, Manik Mia Avenue, Tejgaon, Farmgate, Motijheel, Lalmatia, and Mohakhali. Surveys conducted between January 1990 and December 1999 showed that the concentration of suspended particles goes up to as high as 3000 micrograms per cubic meter (Police Box Farmgate Station, 1999 December), although the allowable limit is 400 micrograms per cubic meter. The nitrogen oxides concentrations at these spots (maximum of 77 micrograms per cubic meter) were below the permissible limit. The sulfur dioxide in the air near Farmgate was found to be 385 micrograms per cubic meter, which is higher than the maximum permissible limit of 100 micrograms per cubic meter. In the Tejgaon Industrial Area

the maximum concentration of SPM was 1849 micrograms per cubic meter (Jan 1997), as opposed to the allowable limit of 500 micrograms per cubic meter. The maximum concentration of air pollutants in Dhaka was during the dry months of December to March, according to a survey conducted by DoE.

The increase in emission of different pollutants over the period 1985 to 1995 is shown in Table 3.3.5. The increase in SPM, SO_2 and NO_x emissions in Dhaka is alarming, and the air quality is obviously deteriorating with time. The air quality in the secondary cities and towns was comparatively better.

The DoE has published air quality data in terms of concentrations of SPM, NO_x and SO_2 in Dhaka City. The increase in concentrations of these pollutants over the last four years is shown in Table 3.3.6 and Figure 3.3.1 shows the seasonal variation of pollutants concentration in the framgate area in the Dhaka City.

Table 3.3.5 Emission Rate (ton/day) Of Different Pollutant Particles In Dhaka City

Year	SPM	SO_2	NO_x	CO	HC	CO_2
1985	4	2	30	118	29	3037
1990	5	3	37	157	42	3885
1995	7	3	44	205	59	4828

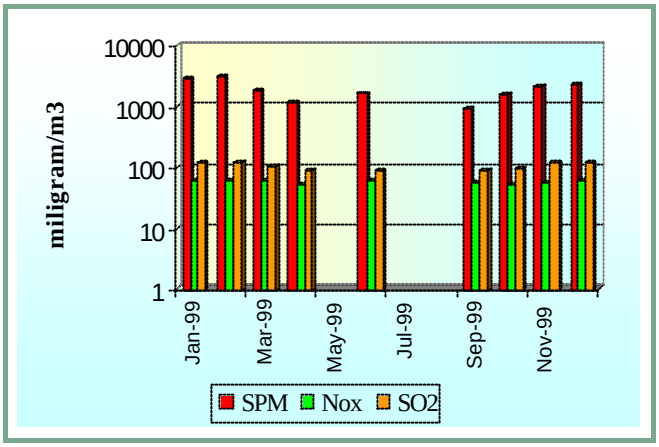
Source: DoE, 1999.

Table 3.3.6 Air Quality of Farmgate area

Pollutant	Dec 1996	Dec 1997	Dec 1998	Dec 1999
SPM µgm/m3	2080.41	1659.6	2485.26	2300.35
NO_xµgm/m3	27.17	41	66.5	58.1
SO_2 µgm/m3	15	66	146.19	121.3

Source: DoE, 2000

Figure 3.3.1 Monthly Variation of Concentration of Pollutants at Farmgate area



Source: DoE, 2000

The Farmgate area was chosen for monitoring because it has among the highest number of vehicles passing through it. Therefore, these figures reflect the upper limit of pollution.

Recently, BAEC reported results from a study on the nature and extent of air pollution in urban and

Table 3.3.7 Average Suspended Airborne Particulate Matter (µg/m^3) during the Collection Periods in Urban Areas of Bangladesh

Location		Coarse (PM 2.5-PM 10)		Fine (PM 2.5)	
		Average	SD	Average	SD
Urban: Dec. '96 - June '98	LRF	68.5	38.5	73.5	25.5
	MRF	61.9	42.3	41.2	22.1
	HRF	27.1	10.3	36.2	23.2
	Overall	58.4	39.9	51.7	27.6
Urban: Aug. '93 - June '94	LRF	139	67	88.0	47.0
	MRF	42.0	28.0	34.0	16.0
	HRF	13.1	4.7	16.8	4.8
	Overall	72.0	69.3	50.7	42.9
Urban: Jan. '95 - Jan. '96	LRF	63.2	23.1	35.1	9.9
	MRF	41.9	37.0	23.7	10.2
	HRF	10.9	4.9	12.2	3.9
	Overall	35.0	32.9	21.1	10.7

Note: LRF- Low rainfall period; MRF- Medium rainfall period; and HRF- High rainfall period

Table 3.3.8 Average Elemental Carbon (μg/m^3) in the Fine Fraction of Airborne Particulate Matter during the Collection Periods in Urban And Rural Areas of Bangladesh

Location	Overall		LRF		MRF		HRF	
	Average	SD	Average	Average	Average	SD	Average	SD
Urban: Aug. '93 - Dec. '94	17.30	16.26	32.33	19.32	10.24	03.32	06.60	01.48
Urban: Dec. '96 - Jun. '98	19.45	10.47	25.64	08.89	18.82	10.14	08.81	02.34
Rural: Jan. '95 - Jan. '96	07.08	03.76	11.00	03.37	07.62	04.31	04.20	01.29

Note: LRF- Low rainfall period; MRF- Medium rainfall period; and HRF- High rainfall period

rural areas of Bangladesh during 1993-1998. This study was based on the realization that from the point of view of health effects, the particle size of Airborne Particulate Matter (APM) is important, as well as its suspension time in air, and hence extent of long distance transportation. In 1993, as part of an internationally coordinated research program by International Atomic Energy Agency (IAEA), BAEC started work on the analysis of the size fractionated APM. Size fractioned samples were collected from both rural and urban areas of Bangladesh over a period of three years. The average mass load in the air during the low rainfall period (LRF) for both fine and course fractions during 1997-98 has been published. It was found that the mass loads of both the APM of particulate mass PM 10 and PM 2.5 were higher that USEPA and WHO standards.

In a paper by M. Khaliquzzaman, S.K. Biswas, S. A. Tarafdar, and A. Islam, at the Mid-Term Review Meeting on 'Air Pollution and Its Trends' (Singapore, October 18-22, 1999), results were presented on the average air particulate mass during the collection period in rural and urban areas of Bangladesh, and average elemental carbon in the fine fraction of airborne particulate matter in these areas. The results are shown in Table 3.3.7 and 3.3.8. Results from monitoring the quality of air in urban areas showed that the concentration of suspended particles in ambient air is many times higher than normal. The conclusion was that the PM 2.5 masses and chemical concentrations are lower in most cases compared to the corresponding PM 2.5- PM 10 values. The ratio of PM 2.5 to PM 10, and the amount of black carbon in the APM are reduced during the high rainfall (HRF) period in both rural and urban sites by about 25 per cent and 20 per cent, respectively.

The Bangladesh Atomic Energy Commission (BAEC) and the Bangladesh Council of Scientific and Industrial Research (BCSIR), in association with the DoE, recently conducted research studies primarily aimed at measuring the concentration of lead in the ambient air. The Dhaka Shishu (Children's) Hospital also conducted research in association with the BAEC on the level of lead in the blood of children of Dhaka city, and also studied the possible impact of leaded gasoline on them. The Bangladesh Road Transport Authority (BRTA) is also setting up a vehicle emission monitoring station at Mirpur, Dhaka.

The survey conducted by the scientists of Bangladesh Atomic Energy Commission (BAEC) prior to introduction of unleaded gasoline showed that the air that city dwellers breathe on the roads contains lead in concentrations almost ten times above the government safety standard set by the DoE. The BAEC study found alarmingly high quantity of lead in the air of Dhaka city which was 463 nanograms per cubic meter - the highest in the world. Figures for lead concentrations in other major cities in the world, in nanograms per cubic meter as reported in the same report were 383 in Mexico City, 360 in Bombay, and only 70 in Los Angeles.

The Department of Environment also conducted a study for lead levels in three different areas of Dhaka city, from November 96 to March 97. They found the level to be 123-252 nanograms per cubic meter at Farmgate area, and 61 to 76 nanograms per cubic meter in Tejgaon Industrial area.

However, during July 1999 the GoB executed the decision to provide only unleaded gasoline in the country. According to recent measurements between late 1999 and 2000 by BAEC and Eastern Refinery Ltd (ERL), the gasoline dispensed at pumps in

Bangladesh is now confirmedly free of lead (Shah *et. al.*, 1999). However, measurements on lead levels in ambient air after introduction of unleaded gasoline are still not available.

This is a classic example of heightened awareness campaigns initiated by civil society (see box).

UNLEADED GASOLINE IN BANGLADESH – A MAJOR SUCCESS STORY

On July 1, 1999, the Government of Bangladesh executed the landmark decision of providing only unleaded gasoline. According to recent measurements by the Bangladesh Atomic Energy Commission and Eastern Refinery (late 1999 and early 2000) have confirmed that gasoline dispensed at pumps in Bangladesh is now free of lead By going lead-free virtually overnight, Bangladesh has become a model for other countries in the developing world that are working to eliminate the harmful pollutant from gasoline.

Lead is a major environmental health hazard and is the number one environmental disease among young children in developing countries, according to the World Bank, which has been providing technical assistance to the Government of Bangladesh and other countries the lead phase-out issue.

The full impact of lead poisoning on the health of children and adults is becoming clearer to most countries, and many governments have begun to take action. Bangladesh joins the ranks of countries such as the US, UK, Germany, and Thailand that have taken aggressive steps to combat lead poisoning, which has resulted in significant health and economic benefits in the countries. In developing countries, however, actions have been slower and sporadic.

How it was done in Bangladesh

The problem of lead pollution in the capital city Dhaka was identified as early as 1980. However, little data was available until 1991 when high levels of lead in samples of suspended particles in air were reported. The chemical analysis of the samples clearly identified the presence of lead and their gasoline origin. In 1995 the need to address lead pollution was raised by different government agencies, environmental and health advocates and international organizations such as the IAEA and the World Bank. The issue received considerable attention in seminars, symposia, and the press, and the options for introducing unleaded gasoline were discussed with the Eastern Refinery, Chittagong which is the only installation producing petroleum products in the country.

Heightened awareness of the dangers of lead pollution prompted the agencies concerned with the production and marketing of petroleum products and the Ministry of Energy to begin taking action. In 1997, lead content was reduced from 0.8 g/liter in the 1980s to an average of 0.4 g/liter by blending locally refined leaded gasoline with imported unleaded gasoline. In 1998, low octane gasoline was made lead free, but high octane gasoline still contained 0.4 g/liter of lead. The increasing share of unleaded gasoline was achieved by importing only unleaded gasoline to make up for the difference between domestic supply and demand. Growing public pressure encouraged the National Environment Council to adopt a resolution to switch to unleaded gasoline in 1998, and subsequently the Ministry of Energy made the decision to go lead free last year.

Recently, Prof. Abul Hussam of George Mason University, Virginia, USA, (August, 1998), detected 200 organic compounds by analyzing four air samples collected from the Shewrapara area of the city, and identified 35 of them.

One emerging problem is the ground level ozone pollution level in urban areas. This major component of "smog" forms when oxides of nitrogen and volatile organic compounds (VOCs) chemically react in warm temperatures and sunlight. Ground level ozone can create a serious health hazard. It can exacerbate the symptoms of asthma, cause significant damage to lung cells, and reduce the ability of lungs to fight infection.

Transboundary Air Pollution

It can be said with certainty that there is trans-boundary pollution from our neighboring countries, because of the seasonal variation in wind direction. No data on this topic is yet available as there are no suitably located monitoring facilities for the purpose. However, recently UNEP has taken an initiative to set up a few monitoring stations. After ascertaining the extent of trans-boundary pollution, policies for mitigation can be developed in cooperation with neighboring countries.

3.3.4 IMPACTS OF AIR POLLUTION

Areas in the South Asian region undergoing rapid urbanization and industrialization are now

experiencing unacceptable air quality, and rapid growth of vehicle numbers. A person inhales an average of about 16 m^3 of air per day, and thus its quality is obviously a concern for humans, as well as other living beings. Acceptable ambient air quality is also required for preserving structures and historical monuments. Air pollutants lead to acid rain falling on forests, crops and aquatic ecosystems, which compromises their condition. The country has a few studies on the impacts of air pollution on human health, and virtually no study on its impacts on ecosystems, livestock, and vegetation. The following Table 3.3.9 shows the pollutant sources and the impacts of air pollution in a broader context, highlighting international findings.

3.3.4.1 Impacts on Human Health

According to the World Health Organization, health is a "state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity". The air we breathe not only has life-supporting properties, but also life-damaging properties, particularly when the balance among the air components is disturbed, or otherwise becomes polluted. All the impurities in inhaled air do not necessarily cause harm. The prime factors affecting human health are the nature of a pollutant, concentration of pollutants, duration of exposure, and the state of health and age group of recipients.

A descriptive cross sectional study on lead levels was conducted in selected areas of Dhaka city by a

Table 3.3.9 Pollutants, Sources, and the Impacts of Air Pollution

Pollutants	Sources	Impacts
1. Suspended Particulate Matter (SPM)	Motor vehicles Wood-burning Industrial activities	Respiratory infection Throat irritation Aggravated asthma
2. Sulfur Oxides	Vehicles (diesel-using) Factory emissions	Affect respiratory tract and permanent lung damage Bronchitis Emphysema Asthma Plant growth reduction Beans and tomatoes with bleached colorless spots
3. Nitrogen Oxides	Vehicle motors Power stations	Respiratory diseases Chest congestion Eye irritation Headache Suppressed growth of beans and tomatoes Increase abscission and reduce yield in citrus plants Spots and mild necrosis on cotton and bean plants Acute leaf failure
4. Lead	Windblown dust Vehicles Coal & wood-burning Metal production Phosphate fertilizer	Affected central nervous system Renal damage Hypertension Children are 3 times more at risk than adult Effects on plants
5. Carbon Monoxide	Petrol vehicles (2 and 3 wheelers)	Reduces the ability of blood to carry oxygen Exacerbates heart disorders
6. Aromatic Hydrocarbons	Unburned fuel from diesel engines	Drowsiness Eye irritation
7. Benzene	Unleaded petrol Emitted from catalytic converters	Carcinogen Affected central nervous system
8. Ozone	Reaction between VOCs and NO_X in presence of sunlight	Reduced lung function Asthma Eye irritation Nasal congestion Lowered resistance to infection

Source: Philip Gain, 1998

researcher at the Department of Occupational and Environmental Health, NIPSOM, on rickshaw pullers, baby-taxi drivers, traffic police, tempo assistants, and petrol pump operators (NIPSOM, 2000). The study found that the mean blood lead levels were: rickshaw pullers 248 micrograms/dl (range 154-344 micrograms/dl), baby-taxi drivers 287 micrograms/dl (range 161-372 micrograms/dl), traffic police 272 micrograms/dl (range 152-32 micrograms/dl), tempo assistants 255 micrograms/dl, and petrol pump operators 249 micrograms/dl (mean 207-342 micrograms/dl). The mean blood lead level among these risk groups was found to be higher than the acceptable value, with traffic police being the worst affected group. The study also noted that blood lead levels increased with duration of exposure.

Most recently lead poisoning has been found in children at the Shishu Bikash Kendro (Child Development Centre) of Dhaka Shishu (Children) Hospital, causing developmental delay and neurological impairments. Lead concentrations measured around 80 micrograms/dl to 180 micrograms/dl in the tested children's blood, which is 7-16 times more than the acceptable limit (Khan, 2000). The safe concentration advocated by the U.S. Center for Disease Control and Prevention is 10 micrograms/dl (1999). Researchers also identified a significant rise in mean blood lead levels in people living in urban slums, compared to those living in urban middle-income or rural areas.

Until these recent studies conducted by the Dhaka Children's Hospital and Bangladesh Atomic Energy Commission found high levels of lead in the blood samples of children in Dhaka, the air problems in the country were not addressed with much importance.

In addition, it has been found that Dhaka city has volatile organic compounds beyond tolerable limits, some of which cause cancer. Emissions from two stroke auto-rickshaws in Dhaka were found to contain 4 to 7 times the maximum permissible level of VOC. (M. Alauddin, August 1998).

3.3.4.2 Impacts on Livestock

An interest in the effects of air pollution on animals has generally developed as a corollary to concern about human health. Livestock get poisoned through a two-step process; firstly there is an accumulation of airborne contaminants in the vegetation and fodder, followed by subsequent poisoning of the animals when they eat this contaminated vegetation and fodder.

3.3.4.3 Impacts on Vegetation

Air pollution has long been known to have an adverse effect on plants. A number of air pollutants affect plants, but the commonly encountered ones are sulfur dioxide, nitrogen oxides, and ammonia. Absorption of pollutant gases by plants depends primarily on light intensity, humidity, moisture supply to roots, and temperature. Therefore, knowing pollutant concentrations, and trans-boundary migration of pollutants alone is not enough for assessing the impacts. Moreover, mitigation requires an integrated approach that considers seasonal variability of the weather.

3.3.4.4 Impacts on Ecosystem

There is also a direct impact from air pollution on aquatic ecosystems through acid rain. Transportation of air pollutants occurs not only through wind movement, but also by water flow. Therefore, an integrated regional level assessment is required.

3.3.5 RESPONSES BY DIFFERENT AGENCIES

3.3.5.1 Policies, Roles and Regulatory Responses

Every country needs a practical and dynamic set of rules and regulations to prevent and mitigate environmental pollution. The environmental laws existing in Bangladesh may be categorized on the basis of broad objectives as follows:

- Protection of environmental health
- Control of environmental pollution
- Conservation of natural and cultural resources.

The first regulation related to environment in Bangladesh was the Factory Act of 1965, through which workers' health-related issues were addressed. This was followed by the earliest recorded environmental protection act, known as the "Water Pollution Control Ordinance, 1970". However, none of these ordinances addressed air pollution problems. This major oversight may have been due to the almost negligible air pollution

problems at that time. In view of growing environmental pollution this ordinance was repealed, and the Environmental Pollution Control Ordinance (EPC), 1977, was promulgated. This ordinance provided for the control, prevention, and abatement of pollution of the environment in Bangladesh. It dealt with pollution of air, surface and ground waters, and soil by discharge of liquid, gaseous, solid, radioactive, or other substances. Although the order passed under the EPC 1977, was legally in place, implementation of environmental laws never took place.

The environmental scenario in Bangladesh changed considerably following rapid industrialization. The Ministry of Environment and Forest, and the Department of Environment were created in 1989. As a signatory to Agenda 21, Bangladesh is committed to implement this international legal instrument through national programs and policies. The Environment Policy of 1992 was an important development in this regard. Further, the Environmental Conservation Act, 1995, and the Environment Conservation Rules, 1997, were approved by the Bangladesh National Assembly to restrict and mitigate ever-growing environmental problems in the country.

Therefore, the Bangladesh National Environmental Policy 1992, Environmental Conservation Act 1995, and the Environmental Conservation Rules (ECR) 1997, now contain relevant policies, such as authority to inspect and regulate facilities, collect samples, impose civil penalties, adopt rules, and implement environmental clearances (see Table 3.3.10). Under the Rules of 1997, the following standards have been set.

- Ambient Air Quality Standards
- Vehicular Exhaust Emission Standards
- River Transport (Mechanized) Emission Standards
- Standards for Gaseous Emission for Industries or Projects

3.3.5.2 Recent Government Decisions

Recently the Ministry of Energy and Mineral Resources (MEMR) has taken important decisions in this connection, as follows:

(i) The minimum standard of lubricating oil for two-stroke engine should be APITC or JASOFB.

(ii) Marketing of straight mineral oil should stop immediately. If anyone sells straight mineral oil,

Table 3.3.10 Policy Responses to Air Pollution through Acts, Rules, and Laws in Bangladesh

Act/Rule/Law	Control/Prevention Response
A. The Brick Burning (Control) Act, 1989 (Act number 8 of 1989) B. **The Brick Burning (Control) Amendment Act, 1992**	• Control of brick-burning • **Required a license from the appropriate authority** • **Restricts brick-burning with fuel wood**
C. Bangladesh Environmental Conservation Act, 1995 (ECA 1995)	• Declaration of ecologically critical areas • Regulation with respect to vehicles emitting smoke harmful for the environment • Environmental clearance • Regulations of the industries and other development activities-discharge permit • Promulgation of standards for quality of air, water, noise, and soils for different areas and for different purposes • Promulgation of acceptable limits for discharging and emitting waste
D. Environment Conservation Rules, 1997 (ECR, 1997)	• The National Environmental Quality standards for ambient air, various types of water, industrial effluent, emission, noise, vehicular exhaust, etc • Requirement for the procedures to obtain environment clearance • Requirement for IEE/EIA according to categories of industrial and other development inventories
E. Environment Court Law, 2000	Government has given highest priority to environment pollution and passed 'Environment Court Act 2000' for completing environment related legal proceedings effectively

he should be penalized. Bangladesh Petroleum Corporation (BPC) will circulate this information in the newspaper, and ensure implementation properly. A monitoring cell should be constituted by BPC.

(iii) BPC will mention the minimum standard of lubricating oil determined by the Government when signing agreements with private companies.

(iv) To protect the environment appropriate regulations are to be enacted on disposal of used lubricants.

(v) All blending plants (including private) should be of international standard, and must be upgraded with laboratory facilities.

(vi) Marketing of products in small packs is to be encouraged, and a committee is to be constituted to determine the packing standard.

(vii) A well-equipped and effective laboratory is to be established for testing lubricants and fuel oils.

3.3.5.3 Other Possible Policy Initiatives

1) Promulgation of new laws and modification of old laws to strengthen controlling authority.

2) Banning import of two-stroke engines.

3) Phase-wise plan to take two-stroke engine vehicles off the roads.

4) Imposing extensive penalties on polluters and industries.

5) Motivating the public through promotional activities to use less polluting vehicles.

6) Increasing the number of public vehicles (such as buses, double-deckers, etc.) to reduce the number of vehicles on the streets.

7) Remove traffic congestion by reducing the member of non-motorized vehicles, and by restricting the movement of such vehicles within a certain part of the city, and during a specific period of the day.

8) 8) Improving the mass-transport system within the urban areas, and increasing parking facility.

9) Regular monitoring of the ambient air quality and vehicular emissions.

10 Public awareness campaigns.

11) Proper implementation of present laws.

12) Promulgate standards for ground level ozone concentration within the ECA 95 and ECR 97.

13) Ensure through promulgating law that are existing and imported vehicles be fitted with catalytic converters.

3.3.5.4 Program Responses

A. Fuel switching

In 1985-86 the Bangladesh Petroleum Corporation started a project to use Compressed Natural Gas (CNG) in vehicles instead of gasoline. The primary objective was to reduce vehicular emissions, as combustion of CNG produces less pollution than gasoline. The World Bank donated Taka 225 million to initiate the project.

Data on the number of vehicles converted to CNG-driven ones over the last nine years are shown in Table 3.3.11. It indicates that a negligible number of cars have been converted for CNG. This is due to lack of promotional activity, reluctance of people to embrace a new technology, unavailability of filling stations, maintenance, etc. However, its use may increase with the appropriate push from the Government and by increasing the promotional campaign, which will eventually reduce vehicular emissions. On the other hand, private sector participation in using CNG, particularly for taxicabs, has started and the numbers are significant.

Table 3.3.11 Number of Vehicles Converted to CNG

Year	No. of Vehicles Converted
1985-86	2
1988-89	19
1989-90	9
1990-91	6
1991-92	10
1992-93	16
1993-94	3
1995-96	13
1996-97	86

Source: National Action Plan of Air Pollution, 1999

B. Control Options Applied and Abatement efficiency

In order to control and limit vehicular exhaust especially in the urban area, several initiatives has been undertaken by the GoB which is described in Table 3.3.12.

Table 3.3.12 Control Options Applied and Abatement Efficiency

Source	Control option applied	Abatement efficiency
Vehicular air pollution (mainly urban-based)	Phase out of leaded gasoline in July 1999, import of unleaded gasoline is implemented Banning new licenses and road permits for two-stroke engine three-wheelers (baby-taxis) in Dhaka City is implemented in the first phase Introduction of low Sulfur content fuels Introducing 2T lubricants mandated from 1 January 2001 but not implemented Building infrastructure and incentives to promote CNG as a vehicular fuel	Decision taken by the Government and implementation process is under way. Sulfur ..... to 0.5 per cent from 1 per cent. 51 filling stations to be installed in 10 years.

C. Air Quality Management Project (AQMP)

The DoE has undertaken a project on Air Quality Management, which is being funded by the World Bank. The project has the following two components:

Component-1: Enforcement, Standards, and Pilot Control Programs

This component that is essential for long-term success of emissions reduction measures will include; (i) enforcement of emissions regulations for in-use vehicles; (ii) development of fuel standards (petrol and lubrication oil), and vehicle emission standards; and (iii) pilot studies for vehicular pollution control.

Component-2: Air Quality Monitoring and Evaluation

This component will generate essential air quality information, and evaluate pilot activities listed in Component-1. It will include, (i) air quality monitoring in Dhaka; (ii) awareness raising campaigns; and (iii) air quality management assessment for strategy formulation.

3.3.6 OPTIONS FOR AIR POLLUTION MANAGEMENT

There are a few low cost measures that could make a substantial dent in the emissions from vehicles with two-stroke engines, which are the major causes of air pollution in Bangladesh, especially Dhaka city. Among these the following are probably the most significant, and discussed in more detail.

- Use of low smoke 2T lube oil for two-stroke engines
- Inspection and maintenance
- Traffic management

Use of low smoke lube oil for two stroke engines

Specially formulated lubricants for two-stroke engines (JASO-FB/FC) with low smoke are now available from major oil companies. These are usually referred to as '2T' oils or lubes. It is known that these better-quality lubricating oils can decrease emissions by half. Recently GoB has mandated the use of 2T lubricants in two stroke engine vehicles from 1 January 2001 but it is yet to be implemented due to supply problem.

Inspection and maintenance

It is known that emission from engines can be reduced substantially through proper inspection and maintenance. For example the effectiveness of this measure in the case of two-stroke engines would be a reduction of up to 35 per cent in emissions. The increase in maintenance cost would be offset by the better engine performance, and resulting reduction of fuel cost. The benefits would include reduced health maintenance costs, and lower mortality.

Traffic management

Traffic management refers primarily to measures that address traffic congestion. Successful traffic management reduces congestion and thus emission by diminishing idling vehicles, the need for acceleration

and deceleration, and fuel consumption. The major components required are:

- Traffic signals
- Introduction of one-way roads
- Improving parking facilities
- Coordination of different vehicular modes
- Separate lanes for different speed traffic

Special Option for Dhaka

The presence of very low speed non-motorized vehicles (mainly rickshaws) with a maximum speed of 10 km/hour, and their interaction with motorized traffic presents a very special traffic problem. Rickshaws cannot be removed due to socio-economic constraints. Hence, creative measures are needed to limit the impact of non-motorized traffic. Some of these have already been tried sporadically, on a limited scale, but what is needed is a long-term commitment, and substantially scaled-up operations.

A suggested measure for Dhaka city is that non-motorized traffic is restricted from arterial roads, with some exceptions for the circulation of such traffic. The exceptions would consist of non-interactive special lanes and crossings, to maintain non-motorized flow between different regions. Some expected effects from this measure that will reduce pollution would be that traffic flow-speed will increase, and fuel consumption will be reduced for the same vehicle-miles traveled.

3.3.7 CONCLUSION & RECOMMENDATIONS

The ultimate success of any decision is the extent to which it translates into action. It is apparent from the discussion above that it is possible to reduce emissions from vehicles with two-stroke engines by about two thirds through the use of low smoke lubricants, and proper inspection and maintenance.

Some additional decisions and actions to reduce air pollution caused by two-stroke engine baby-taxis are needed to really improve the air quality. Some of these are given below.

- GoB decision on mandatory use of 2T lubricant should be strictly enforced
- Introduction of sachet packs of 2T lubricant of JASOFB standard should be done as soon as possible, as these can be afforded by the drivers.
- A suitable set of standards of emission for the two-stroke engine baby-taxis and other vehicles to be promulgated, as current standards are not appropriate. DoE can promulgate such standards.
- Effective enforcement of vehicle compliance to these standards has to be ensured. This could be a multi-agency enterprise. For example, through the vehicle registration process the Bangladesh Road Transport Authority could ensure compliance at the time of registration. DoE can do spot checks of vehicular emissions under the Environmental Protection Act.
- These checks must be done using reliable equipment with printed outputs, so that transparency is ensured, because otherwise public support for the checks cannot be maintained.
- Enforcement program inspectors should be adequately trained.
- If sufficient manpower or equipment is not available at Government agencies for enforcement work, some type of distributed system should be developed through the private sector.
- Provision for repair at reasonable cost has to be ensured for vehicles that fail enforcement test procedures. For this adequate attention to repair procedures, and mechanic training has to be given.
- Periodic evaluation and review of all the actions and issues should be done to identify problems and find their solutions.

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