DELHI'S ENVIRONMENTAL ISSUES: ECONOMIST'S SOLUTION

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Environmental issues are currently receiving a great deal of attention. In the state of Delhi more than three thousand industrial units have been sealed and moves are afoot to close 95000 other units in nonconforming areas. In this paper, authors have presented status report on various types of pollution in Delhi to highlight the exact, data based extent of the problem and have examined approaches to tackle the problem.

INTRODUCTION

Currently, considerable discussion is going in the country on pollution and its economics. In the wake of the current upheaval and violence in the state of Delhi on the issue of shifting of the industrial units brought about by judicial activism fierce debate is going on regarding the approach towards tackling the problem of pollution in general and industrial pollution in particular. While there is no doubt that pollution has reached alarming levels and serious efforts must be made to tackle the problem, few efforts have been made to collect the data relating to pollution in a comprehensive and systematic manner. The present study is aimed at filling this gap in the literature. The study is divided into two sections. Section-I examines the status of environment in the state of Delhi,. Section-II examines the alternative app-roaches available for tackling the problem.

SECTION-I

This section presents and analyses the state of various aspects of environmental pollution in the state of Delhi

1. AIR QUALITY STATUS

It is estimated that about 3,000 MT of air pollutants are emitted everyday in Delhi. The sources of air pollution in Delhi are given in Table 1 below with their contribution to air pollution load:

Table1 : Sources of Air Pollution in Delhi

Source	Contribution (%)
Vehicular emissions.	67
Coal based thermal power plants	13
Industrial unit	12
Domestic and commercial activities.	8

Source: White Paper, MoEF, 1997

1.1 Ambient Air Quality

The CPCB (Central Pollution Control Boared) has been monitoring the ambient air quality at various locations in Delhi

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measuring sulphur dioxide, oxides of nitrogen and particulate matter under the National Ambient Air Quality Monitoring Programme. The standard for ambient air quality are given in Table 2.

Table 2 : National Ambient Air Quality Standards

Pollutant	Time-Weighted Avg.	Concentration in Air		
		Industrial	Residential	Sensitive
NO_2	Annual avg.	80	60	15
(μgm/cu.m)	24 Hrs. avg.	120	80	30
SO_2	Annual avg.	80	60	15
(μgm/cu.m)	24 Hrs. avg.	120	80	30
SPM	Annual avg.	360	140	70
(μgm/cu.m)	24 Hrs. avg.	500	200	100
RPM	Annual avg.	120	60	50
(μgm/cu.m)	24 Hrs. avg.	150	100	75
LEAD	Annual avg.	1.0	0.75	0.50
	24 Hrs. avg.	1.5	1.00	0.75
CO	8 Hrs avg.	5.0	2.0	1.0
(mg/cu.m)	1 Hrs. avg.	10.0	4.0	2.0

Note : 1. Annual Arithmetic mean of minimum measurements in a year taken twice a week 24 hourly at uniform interval.

2. 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

Source : CPCB 1999

The data are available in NAAQMS (National Ambient Air Quality Series) series reports of CPCB (Central Pollution Control Board) for 9 monitoring stations, out of which 6 are being monitored by CPCB located at Ashok Vihar, Shahzada bagh, Siri Fort, Janakpuri, Nizamuddin, Shahdara and other 3 by NEERI at Town Hall, N.Y School (Sarojini nagar) and E.S.I Dispensery (Najafgarh road). The data for three monitored parameters SO_2, NO_x and SPM for their annual average values for the years 1987 to 1998 were used for assessment of air quality trends at different stations (Appendix-I,)From the data following conclusions can be drawn:

SO_2 (Sulphur Dioxide)

The presence of sulphur dioxide (SO_2) in the air of Delhi state is presented in appendix-I.

The following observations can be drawn from these:

* The Town Hall has higher level of annual average values of SO_2 as

compared to other stations.

* The stations at Ashok Vihar, Nizamuddin and Shahdara show the increasing trend of annual averages values, while Najafgarh and Sahzadabagh show the decreasing trend of annual average values.

* The trend is not clear at Town Hall and Sarojini Nagar stations.

NO_x (Oxides of Nitrogen)

The presence of Oxides of Nitrogen (NOx) in the air of Delhi state is presented in appendix-I. Following observations can be drawn :

* The higher values of annual average of NOx occur at Town Hall followed by Sarojini Nagar and ESI Dispensary.

* The status at Siri fort , Nizamuddin, Shazadabagh and Jankapuri shows increasing trend of annual average values of NOx followed by marginal decrease in last two years.

* The status of Ashok Vihar and Shahdara show increasing trend of annual average values of NOx up to the year 1992 and decreasing trend of annual average value of NOx from the year 1993 onwards.

SPM (Suspended Particulate Matter)

The presence of Suspended Particulate Matter (SPM) in the air of Delhi state is presented in appendix -I The tables show :

* The higher values of SPM occur at Town Hall which remained high consistently over the years.

* The levels of SPM at Janakpuri, Nizamuddin and Shahdara shows decreasing trend in recent years.

The results of the study done by CPCB to represent the overall Ambient Air Quality is given in Table 3 below :

Table 3 : Ambient Air Quality

	1995	1998	% Reduction as compared to 1995
Industrial Area			
SO_2 (µg/cu.m)	24.1	20.2	16
NO_2(µg/cu.m)	35.5	34.7	4
SPM (µg/cu.m)	420	367	13
Lead (µg/cu.m)	110	105	5
Residential Area			
SO_2 (µg/cu.m)	16.5	15.8	4
NO_2 (µg/cu.m)	32.5	28.6	13
SPM (µg/cu.m)	409	341	17
Lead (ng/cu.m)	155	95	39

Table 3 (Contd.)

Traffic Intersections			
SO_2 (µg/cu.m)	42	25	40
NO_2 (µg/cu.m)	66	63	5
SPM (µg/cu.m)	452	426	6
Lead (ng/cu.m)	335	136	60
CO (µg/cu.m)	5587	5450	3

Source : CPCB (1999)

It may be observed from Table 3, the ambient air quality of Delhi shows that pollution has decreased by 4-40% in case of SO_2, 4-13% in case of NO_2, 6-17% in case of Particulate Matter, 3% in case of carbon monoxide and 5 to 60% in case of lead during 1998-1995 . However decline is not significant in as much as the level of pollutants continues to remain much higher than the levels considered safe for human beings.

1.2 Vehicular Emissions

Due to the increase in the number of motor vehicles at exponential rate, vehicular exhaust has become a major source of air pollution in Delhi contributing the 67% of the pollution load (Table 1). Among the metro-cities, Delhi is most severely affected with the highest number of motor vehicles and as much as 70% of the air pollution is attributed to vehicular exhaust.

Based on the inputs form CPCB and discussion with, the concerned agencies some of the priority measures and time targets for vehicular pollution control were worked out which the Hon'ble Supreme Court subsequently approved with the direction for implementation. Some of these measures are given below:

* Complete removal of leaded petrol in NCT;
* Phasing out 15 year old commercial vehicles;
* Installation of pre-mix 2T oil dispensers in petrol filling stations;
* Expansion of CNG supply network;
* Removing the old buses (more than 8 year) from the roads;
* All buses to switch over to CNG from of Diesel;
* New Inter state Bus Terminus to be set up at entry points in north and south west to avoid congestion and pollution due to entry of interstate buses;
* Automatic inspection and certification facilities to be set-up for commercial vehicles in the first phase; and
* Augmentation of air quality monitoring network.

The CPCB has done a study to find out the future pollution load in two scenarios. In scenario one, estimates were made considering no abatement measures were adopted and in scenario two estimates were made considering various abatement measures were adopted. The results are given in Table 4. For controlling vehicular pollution, the Government has taken some important measures as described above in recent years (1999-2000).

Table 4 : Estimated Vehicular Pollution Load in Delhi

Pollutant	Pollution Load (in Thousand Tonnes/day)					% Reduction as Compared to 1995-96
	Without Anit Pollution measures			With Anti Pollution measures		
	1990-91	1995-96	1998-99	1995-96	1998-99	
CO	243	373	451	351	337	4
HC	82	123	148	113	115	+2
NO_x	139	208	248	207	182	12
SO_2	10	15	17	15	11	27
LEAD	0.190	0.259	0.362	0.259	0.007	97
PM	19	28	33	28	21	25
Total Pollution Load	394	747	897	714	666	
Emission Load in T/D	1351	2047	2459	1957	1825	

Source : CPCB 1999

It can be seen from Table-4, due to increase in number of vehicles, the vehicular pollution load was estimated to increase substantially over the eight year period spanning 1990-91 and 1998-99. However, with the implementation of emission norms and fuel quality specifications, phasing out of 15-year old vehicles and introduction of unleaded gasoline, the pollution load decreased in 1998-99. The ambient air quality monitored in different areas (residential, industrial and traffic intersection) shows reduction in levels of pollutants between 1995 (before introducing the measures) and 1998 after the introduction (Table 3). However, level of pollution continues to be higher than the prescribed safe limits despite the reduction in pollution level.

1.3 Thermal Power Plants

The second major contributor to the air pollution, accounting for 13 % of total air pollution load, in Delhi is power plants located in the city. There are two thermal power stations situated right at the center of the city - Rajghat Thermal Power Station (RTPS) and Indraprastha Thermal Power

Table 5 : Fly- ash Generation from the Power Plants in Delhi

Station	Capacity	Fly-ash (in Tonnes/day)
Indraprastha	283.5 MW	1200-1500
Rajghat	135 MW	600-800
Badarpur	720 MW	3500-4000

Station (ITPS). The third one is at the southern end - Badarpur Thermal Power Station (BTPS). The RTPS and ITPS together produce 418 MW of power and emit 3.8 tonnes of pollutants every hour. These two thermal power stations have often made headlines for the plumes of smoke released by them into the atmosphere. The Delhi Pollution Control Committee (DPCC) has been trying to force the Delhi Vidyut Board (DVB), which operates these power plants, to control the emissions. Both the thermal power stations together release 2722 tonnes of pollutants every month into the air (NIUA, 1994).

Another major problem related with these power plants is disposal of fly-ash. About 6,000 tonnes of fly ash is produced by the thermal power plants in Delhi. The fly-ash generation from each of these plants is given in Table 5 above.

Although the part of fly-ash is being used for various purposes (brick making, road construction and filling low lying areas), major portion is being dispersed off in the river beds of Yamuna, thus causing obvious risk to the river water quality.

1.4 Emission from Industries

The large number of industries within the city also pose a serious threat to the air of the city. Out of total 1,25,000 industries located in Delhi, 98,000 are in non - conforming (located in un-authorized areas, 'lal dora', villages, resettlement colonies, the walled city and other residential pockets) area as per Master Plan of Delhi. The industries although, are under legal obligation to comply with the emission standards, but rarely follow the order. The data on the emission from various types of industries are not available at the moment to assess the level of pollutants released by them. The emission load from industries contribute 12 % of total air pollution in Delhi (White Paper, MoEF, 1997).

1.5 Residential and Commercial Activities

The air pollution contribution from residential and commercial areas is only 8 % of the total (White Paper, MoEF, 1997). As the economic status of residents grew, the commercial activities started growing at fast pace. This, in turn created huge electricity demand and put excessive pressure on the electricity generation and distribution system leading to frequent breakdowns. The Government has failed to regulate the large demand of electricity, which puts the ball in residents court to seek the solution.

The solution adopted by the residents and entrepreneurs is to install 'Generators' for individual units. Unfortunately this solution has been causing huge environmental cost in the form of air pollution. In addition, the burning of leaves and garbage in various places is a common practice through out the year, but during winter it creates air pollution of local environment.

Table 6 :·Water Abstraction in Delhi Stretch of Yamuna River (million cubic meters)

Abstraction point	Irritations	Water Supply	Others	Total
Wazirabad	-	275	75	350
Wazirabad-Okhla stretch	1500	-	10	1510
Total	1500	275	85	1860

2. SURFACE WATER

The surface water in Delhi is available in river Yamuna, Najafgarh drain, other smaller water bodies (tanks and lakes) and in the form of stagnated water pools at various places.

'River Yamuna' , which is the main source of water supply in Delhi, plays a crucial role in its growth. Phenomenal increase of population and urban activities in Delhi are posing extremes pressures and demands on this natural riverine resource.

The river Yamuna enters Delhi at Wazirabad and leaves at Okhla Barrage. The availability of water in river Yamuna varies with time and space. Yamuna carries about 80% water during monsoon, while during rest of the year only 20%. The catchment of Yamuna river spreads over 3,45,848 sq.km., out of which Uttar Pradesh has 21.5 % catchment area, Himachal Pradesh (1.6 %), Haryana (6.1%), Rajasthan (29:8%), Madhya Pradesh (40.6%) and NCT (0.4%). The Yamuna river water abstraction in Delhi for different uses is give in Table 6 above.

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Surface water is used for domestic water supply, irrigation and industrial use. Around 275 MCM and 1500 MCM water is used for water supply and irrigation respectively in Delhi.

In-stream use: Other than the uses for domestic, industrial and irrigation purposes, the Yamuna water is being used for community bathing & washing and cattle bathing & washing purposes in Delhi stretch.

YAMUNA RIVER WATER QUALITY

The heavy pressure of water supply and discharge of sewage into river Yamuna in Delhi stretch, leading to severe impact on river water quality. The pollution load from different type of activities and areas is given in Table. 7.

An indicator of river water quality is biological oxygen demand load which shows the extent of oxygen required to decompose organic matter in the river . The higher the BOD load the higher will be the pollution in the river.

Table 7 : Pollution Load on River Yamuna from Delhi

Pollution load on River Yamuna	Discharge Quantity (mld)	BOD Load (MT/d)
From Rural areas of NCT	Insignificant	Insignificant
From Urban areas	~1630*	449.85
From Industries	81	127.3
From other sources**	371.29	105.53

* 1630 mld is from 5 sewerage zones (Okhla, Keshopur, Rithala, Coronation Pillar, Shahdara, total waste water generation in Delhi is 2160 mld.

**Other sources include commercial activities, services shops, institutional area, offices and floating population. MLD-Million litres per day, BOD= Biological oxygen demand MT/d=Metric tonne per day

Table 7 clearly shows that BOD load caused by various activities in yamuna is much higher than the prescribed limit of 50.

The BOD load on river Yamuna is increasing over the years (CPCB, April 2000) as shown in the following Figure 1.

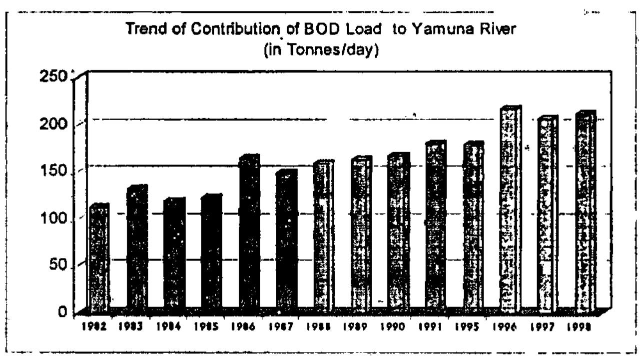

Fig 1. Trend of Contribution of BOD load to Yamuna River in (T/D)

3. GROUND WATER

In Delhi, Central Ground Water Board (CGWB) has monitored the ground water quality for its physio-chemical and biological parameters. For the purpose of assessment of ground water quality, the CGWB has divided the city into six blocks depending on the morphological and hydro-geo-morphological characteristics namely Alipur, Kanjhawala, City, Najafgarh, Mehrauili and Shahdara.

The results of this monitoring are given in Table 8 for the physio-chemical characteristics. The parameters that have been taken into consideration include pH (the index of degree of acidicity, alkalinity and neutrality in water), TDS, (Total dissolved solids), electrical conductivity, nitrate, fluoride and chloride, total hardness, carbonates and bi-carbonates, phosphate, magnesium, calcium, sodium, potassium, silica, boron, etc.

3.1 Ground Water Quality

A) Physio-chemical Parameters

The description of some of the parameters is given below along with their concentration.

Electrical Conductivity (EC)

The electrical conductivity values are having direct correlation with the salinity of the ground water i.e. the saline groundwater has higher EC value. Table 8 shows electrical conductivity levels in various locations in Delhi. It may be observed from the table that while Shahdra and City Blocks are generally having EC ranging between less than 1000 to upto 2000 !mohs/cm, the Alipur, Kanjhawala and Najafgarh Blocks are generally having EC in range of 2000 to 6000 !mohs/cm. However, the EC values higher than 6,000 !mohs/cm have been observed at some patches in Alipur, Najafgarh and Kanjhawala Blocks, where the ground water is saline in nature. The Mehrauli Block is mainly of Quartzite category .It implies that except Shahdra and City blocks the water in other areas is saline and therefore unsuitable for human consumption and use.

Fluoride (F)

In Delhi fluoride concentration of ground water drawn from the depth upto 40 m was within prescribed permissible limit of 1.5 mg/l in about 73% of total groundwater samples collected (including 3.3% samples collected from wells at depth more than 40 m.) The fluoride concentration beyond permissible limit of 1.5 mg/l was observed at considerable number of places. It is observed that fluoride levels are high in Alipur, Kanjhawala and City blocks. The distribution of fluoride in ground water of NCT -Delhi has been depicted in Table 8.

Chlorides (Cl)

The prescribed and permissible limits for chlorides for drinking purposes is 250 mg/l and 1000 mg/l respectively. It has been observed that in Alipur, Kanjhawala and Najafgarh blocks, the chloride concentration in the ground water exceeds the permissible limits (1000 mg/l) at several places .

Nitrates (NO_2)

The prescribed and permissible limits for nitrate for drinking purposes is 45 mg/l and 100 mg/l respectively. It has been observed that in Alipur, Kanjhawala and Najafgarh Blocks, the nitrate concentration in the ground water exceeds the permissible limits (100 mg/l) at several places, while in City and Meharuli in small patches at some of the places.

B) Heavy Metals

Most of the trace metals are of concern because of their harmful effects on human health, plants and environment. Out of these the cadmium, chromium and lead are highly toxic metals to human even in low concentration.

The results for Heavy metal analysis are given in Table 9. The heavy metals in ground water (except iron), which are present in appreciable concentration in ground water have been found below the prescribed maximum permissible limits. Iron in ground water samples was found in concentration ranges between 0.03 and 19.47 mg/l (CGWB, 1999).

The presence of lead, cadmium and chromium was also observed in low concentration. The concentration ranges of Nickel. Zinc and Copper were found below the permissible limits. The presence of heavy metals and their concentration ranges are presented in Table 9. The data for the

Table 8 : Ground Water Quality Characteristics (Physio-chemical) of Ground Water in NCT - Delhi

Location/ Block	Total No. Samples	Depth Range (m)	Electrical Conductivity micro ohms/cm at 25*		TDS		CO_2		HCO_3		Cl		NO_2		F		PO_4		Ca	
			Max	min	Max	min	Max	min	Max	min	Max	min	Max	min	Max	min	Max	min	Max	min
Alipur	39	6-50	7900	767	5875	482	32	nil	794	110	2610	21	277	0.06	5.42	0.13	3.18	0.04	317	20
Kanjhawala	44	4-35	9920	609	7940	410	25	nil	1333	167	2420	28	852	0.01	10.2	0.08	0.38	0.03	501	15
Najafgarh	43	10-60	13200	630	8540	400	nil	nil	1101	225	4461	17	688	1	11	0.21	7.06	nil	619	nil
Mehrauli	40	20-162	4130	320	3210	205	nil	nil	705	117	635	9.9	743	1.1	3.53	0.23	0.2	0.03	264	26
City	81	4-110	10600	225	8460	165	nil	nil	754	95	2060	11	1559	1.5	12.52	0.12	0.38	0.05	451	10
Shahdara	56	6-80	3810	260	2400	235	nil	nil	776	103	1031	14	141	0.02	1.15	0.23	0.65	0.01	194	37

Table 8 : (Contd..) Water Quality Characteristics (Physio-chemical) of Ground Water in NCT - Delhi

Location/ Block	Total No. Samples	Depth Range (m)	Mg (Mg/L)		Na		K		SiO_3		B		Total Hardness		pH		SO_4	
			Max	min	Max	min	Max	min	Max	min	Max	min	Max	min	Max	min	Max	Min
Alipur	39	6-50	326	16	1650	25	213	3.4	35	10	1.19	Nil	1689	150	8.52	7.14	1140	35
Kanjhawala	44	4-35	567	4.6	2500	40	1100	1.6	37	8	3.55	Nil	3553	56	8.46	7.05	2325	52
Najafgarh	43	10-60	595	3.6	1925	65	125	0.8	41	13	1.81	Nil	3325	79	8.42	7.04	990	5
Mehrauli	40	20-162	167	3.4	690	12	9.5	0.6	41	9	1.45	Nil	1221	149	8.2	7.1	450	9
City	81	4-110	541	4.5	1300	7	235	0.08	46	10	0.66	Nil	3551	51	8.61	6.9	2060	8.5
Shahdra	56	6-80	99	5.7	620	6	180	2.5	42	6	0.87	Nil	394	117	7.98	6.9	350	14

Table 9 : Distribution of Heavy Metal in Ground Water in Delhi

	Heavy Metal Concentration in micro gm/l													
Location/ Block	Cd Min	Cd Max	Cr Min	Cr Max	Cu Min	Cu Max	Pb Min	Pb Max	Ni Min	Ni Max	Fe Min	Fe Max	Zn Min	Zn Max
Alipur	NT	0.7	NT	60	NT	80	NT	38	NIL	105	0.11	7.52	NT	2.99
Kanjhawala	NT	0.6	NT	50	NT	80	NT	39	41.7	123	0.03	17.22	NT	3.14
Nagafgarh.	NT	14	NT	20	NT	10	NT	238	NT	161	NIL	5.85	NT	0.06
Mehrauli	NT	2.75	NT	70	NT	120	NT	27	NT	85.61	NIL	4.15	NT	0.5
City	NT	1.7	NT	140	NT	120	NT	39	NT	292	NIL	19.47	NT	2.04
Shahdara	NT	5.3	NT	70	NT	30	NT	22	NT	67.5	NIL	3.37	0.01	1.14
Who	3 micro gm/l		50 micro gm/l		2000 micro gm/l		10 micro gm/l		20 micro gm/l		0.3 mg/l		3 mg/l	

Source : CGWB, 1999

Detection Limits Cadmium : 5 micro gm/l Nickel ; 5 mg/l Chromium : 10 micro gm/, Iron, 0.02 mg/l, Copper : 10 micro gm/l, Zinc- 0.005 mg/l NT = Not traceable assessment of distribution of heavy metals in ground water of NCT - Delhi show that Cd, Cr, Pb, Ni and iron in most of the blocks are above the WHO standards (WHO standards are very lenient as compared to Indian standards).

C) Bacteriological Parameters

The ground water contamination from fecal - coliform bacteria is generally caused by percolation from a contamination source (domestic sewage and septic tank) into the aquifers and also because of poor sanitation. Shallow wells are particularly susceptible to such contamination. The bacteriological contamination of ground water in Delhi is mostly attributable to indiscriminate dumping of waste and garbage without observing any precautions and scientific disposal practices. It has been observed during present ground water survey by CGWB that most of the hand pumps withdraw ground water from upper strata of water table which is most susceptible to contamination from polluted surface water.

The results of CGWB(1999) study indicates that the ground water had significantly high total coliform and fecal coliform contamination (Annexure - II). The bacteriological studies depict the presence of fecal coliform in 5.95% samples, while total coliform were present in 57.99% ground water samples. The presence of total coliform and fecal coliform was mostly reported from hand pumps. Inadequate maintenance of hand pumps and unhygienic condition around the structure might be responsible for poor quality. The most affected blocks with respect to fecal contamination are City block, Shahdara block and Najafgarh block.

Hand pump at Nirankari colony, which is being used for human consumption, was found most unsatisfactory from bacteriological view point. The ground water sample had total coliforms 196/100 ml and fecal coliform 118/100 ml, which may be due to the mixing of recharged water in its aquifer from unlined drain carrying industrial effluents and domestic wastes at 20 m distance. The tube well at Lodhi garden (depth > 40 m) indicated total coliform contamination upto 770 nos./100ml.

In Najafgarh block, the ground water at Raota village, a handpump installed near the road, (adjacent to a pond) has saline water and bacteriologically contaminated (TC=62, FC=18). This water is not suitable for drinking purposes but is being used for drinking by villagers. Similarly , at certain other locations, the coliform values exceeded permissible limit.

The ground water also has been severely contaminated in some areas as indicated by presence of total as well as fecal coliform in collected sample.

3.2 Ground Water Depletion

Due to lack of the water supply in the various parts of the city, the ground water extraction for different uses has emerged as the common phenomenon. The ground water table varies from place to place with seasonal changes. The ground water table in Delhi has been depleting over the years.. At Mehrauli area the depletion is more that 20 m . In South Delhi area it is 12 to 20 m. In the Najafgarh area, the depletion is in the range of 2-12 m. Similar pattern of depletion is present in the northern, north western, central and eastern part of the city.

4. SEWERAGE AND DRAINAGE SYSTEM

Delhi was amongst the first cities in India to have a sewerage system. It is noted that even though sewage treatment capacity in Delhi has been augmented from time to time, the existing capacity of sewerage system in Delhi is grossly inadequate. At present, though 75% of the population is served by the sewer system, much of the sewage through sewer lines, is discharged into the open drains and low lying areas, in the absence of adequate treatment facilities. As a thumb rule about 80% of the total water supplied to the city returns as waste water.

The sewerage system of Delhi is being monitored by Delhi Jal Board (DJB). The sewerage system of Delhi is divided into five zones namely Okhla, Keshopur, Rithala, Coronation Pillar and Shahdara. The total wastewater generation in the city is 2083 mld.

The five sewerage zones of Delhi are catered by the five major Sewerage Treatment Plants and two Oxidation Ponds. These five major Sewage Treatment Plants and two Oxidation Ponds are having total capacity of about 1473 mld (Table 10). Each of these zones has one major STP (Sewerage treatment plant). Besides this, two Oxidation Pond serve Okhla and Rithala zones including Vasantkunj and Timarpur respectively. The total treatment capacity of treatment plants (1473 mld) is inadequate as compared to wastewater generation in the city and hence the significant amount of wastewater with high BOD load remains untreated.

Table10 : Waste Water Discharge Received by Drains in Delhi

Drain	STP	From STPs Flow (MLD)	From STPs BOD (MT/D)	Untrapped Flow (MLD)	Untrapped BOD (MT/D)	Total Flow (MLD)	Total BOD (MT/D)
Najafgarh	Keshopur	272	29.62	950	53.24	1368	90.85
	Rithala	100	5.18				
	C. Pillar	35	2.70				
	Timarpur	11	0.11				
Burari		—	—	239	6.06	239	6.06
Shahdara	Shahdara	46	2.36	390	38.59	436	40.95
Others				217	39.82	217	39.82
	Vasantkunj	9	0.01	219	14.96	228	15.06
Agra Canal	Okhla	474	54.75			474	54.75
	Total	947	94.82	1776	152.67	2723	247.49

Note : Najafgarh drain also receives waste water from Western Yamuna Canal (WJC)
Shahadra drain also receives waste water from Gaziabad and Noida.
Agra Canal also receives untrapped sewage through Kalkaji and Tughlaqabad drains.

Source: CPCB, Highlights - 1999

The treated effluent from STPs other than what is withdrawn for irrigation purposes, joins nearby water bodies. The discharge from Okhla STP goes to Agra canal and from Vasantkunj Oxidation Pond to Kushak - Barapulla drain. The effluent from Shahdara STP finds its way into the Shahdara drain, whereas all other STPs

Table 11 : Industrial Waste Water Discharge in Delhi

	Sewerage Zone	Industrial Area	Estimated Industrial Discharge (mld)	Estimate BOD (mg/L)	Estimated Industrial BOD Load (mt/d)
1	Okhla	Okhla	10.0	941.18	9.41
2	Keshopur	Rohtak Road	1.68	3650	6.12
		Karampura	3.09	3650	11.27
		Mayapuri	7.0	3650	25.34
		Najafgarh Road	7.2	3650	26.28
		Kirtinagar	3.0	3650	10.95
		Naraina	6.0	14.89	0.09
		Mangolpuri	0.56	1057.77	0.60
3	Rithala	Mangolpuri	0.85	1057.77	0.89
		Najafgarh Road	4.80	3650	17.52
		Anand Parbat	8.0	1057.77	8.46
		Lawrence	2.0	1057.77	2.12
		Badli	1.51	274.83	0.42
		Narela	3.21	274.83	0.88
		Wazirpur	10	274.83	2.75
4.	Coronation	Azadpur	1.94	274.83	0.53
	Pillar	Narela	0.54	274.83	0.15
5.	Shahdara	Jilmil	7.0	353.87	2.48
		Patparganj	3.0	353.87	1.06
6.	Total		81.4		127.32

Source : CPCB, April 2000

and Timarpur Oxidation Pond finally discharge into the Najafgarh drain either directly or through various sub - drains. The wastewater not trapped for treatment in STPs finds its way into various drains and sub drains from their respective catchment areas and discharged into the river Yamuna. Thus, a significant volume of wastewater generated, remains untrapped and finds its way into the open drains, nallas or remains in the form of stagnant water pools.

4.1 Industrial Waste Water

Industries generate water pollution loads, which is toxic and varied in nature, highly concentrated in terms of space and time. There are several large, medium and small scale industries, which are located within the 16 major industrial areas in NCT - Delhi. Most of the large and small scale industries have their effluent treatment system, but in the absence of accurate information regarding extent of treatment provided by the industries, this factor has been ignored, while estimating the pollution load generated from industries. The total BOD load discharged by the industrial area has been estimated using discharge and concentration data and the estimated loads are given in Table 11.

The total waste water discharged by the industries is estimated to be 81.4 mld in these sewage zones and the (estimated) total BOD load is 127.32 mt/d.

The government has proposed installation of 15 Common Effluent Treatment Plant (CETP) in different parts of the State. However, given the wide scatter of industrial units these CETPs may not be able to take care of the discharge by all the industrial units.

5. SOLID WASTE

The Municipal Corporation of Delhi (MCD) and New Delhi Municipal Corporation (NDMC) and Cantonment Board are responsible for the collection and disposal of waste in their respective areas of jurisdiction.

5.1 Solid Waste Generation

It is estimated that the solid waste generation in the city of Delhi has increased from 5167.44 tonnes/day in 1996 to 5526.63 tonnes/day in 1998 as shown in the Table 12.

Table 12 : Solid Waste Generation and Collection in Delhi

	1996	1998
Population	1,14,83,213	1,22,81,400
Garbage generation (@ 450 gms/capita/day) in tonnes/day	5167.44	5526.63
Garbage collected (in tonnes/day)	3550.49	5000.00
Backlog (generation - collected in tonnes/day)	1616.95	526.93

Source : ISS, 2000

Table 13 : Status of Solid Waste Collection in Delhi

Zone	Population (1996)	Garbage Collected (T/day)	Number of Sweepers	No. of Sweepers /1000 Pop.	Community Bins (Number)			Number of Vehicles	
					Dalaos	Dustbins	Open Sites	Truck	Front Loaders
City	540896	294.84	1428	2.64	48	32	9	51	10
Central	811995	364.00	2892	3.56	197	17	29	53	14
South	1348961	418.02	5091	3.77	269	31	17	66	15
Karol Bagh	608228	269.36	2889	4.75	68	24	13	49	11
Sadar P. Ganj	521841	269.36	1301	2.49	23	19	0	46	10
West	1341849	241.63	4340	3.23	128	480	41	73	17
Civil Lines	822206	305.76	3707	4.5	14	36	26	58	12
Shahdara (S)	1299410	320.20	4805	3.69	113	66	0	56	13
Shahdara (N)	1377503	276.64	3865	2.8	48	53	5	64	12
Rohini	1202224	426.56	3660	3.04	132	37	31	48	10
Narela	3040294	98.28	1360	4	21	0	0	22	4
Najafgarh	1267806	265.72	2775	2.19	123	49	5	51	4
MCD 96 Total	11493213	3550.49	38113	3.31	1184	421	176	641	142
MCD 98 Total	12281400	5000.00	38113	3.31	1428	798	176	814	0

Source : ISS, 2000.

5.2 Solid Waste Collection

For the purpose of the solid waste management, the city has been divided into 12 zones. The zone-wise details on population, garbage collection (T/day), number of sweepers /1000 population, community bins and machines available are given Table 13. The total garbage collected by MCD in 1996 was 3550 tonnes/day, which increased to about 5000 tonnes/day in 1998 (Table 12). The Table 13 reveals that the garbage collection in South and Rohini zones is higher as compared to other zones of similar population size.

Table 14 : Landfill Sites of Delhi

SLF Site	Area (ha)	Status
1. Gazipur	28.34	Active
2. Bhalswa	16.19	Active
3. Okhla	2.43	Active
4. Ring Road	24.28	Abandoned
5. Chalice Nagar	1.82	Abandoned
6. Timarpur	32.38	Abandoned
7. Tilak Nagar	16.18	Abandoned
8. Chhatarpur	1.72	Abandoned
9. Bhairon Road	2.73	Abandoned
10. SGT Nagar	14.57	Abandoned
11. I.P. Depot	1.82	Abandoned
12. Gopalpur	4.05	Abandoned
13. Sundar Nagari	2.83	Abandoned
14. Tughlakabad Extn.	2.43	Abandoned
15. Haiderpur	1.62	Abandoned
16. Mandawali	2.83	Abandoned
17. SLF Hastal 1	8.09	Abandoned
18. SLF Hastal 2	1.62	Abandoned
19. G.T. Karnal Road	3.23	Abandoned
20. Rohini Phase 3	58.68	Abandoned

Source : ISS Report 2000

5.3 Solid Waste Disposal

The present practices for disposal of the garbage in Sanitary Land -fill sites (SLF), by MCD is extremely primitive and environmentally unsound.

Since 1975 twenty SLFs have been created out of which 15 have already been exhausted and two others have been suspended (Table 14). At present three SLFs are operational at Gazipur, Bhalsawa and Okhla, which have been in use since 1984, 1992 and 1994 respectively. The operational landfill sites are close to exhausting their capacity and in the very near future capital will be in need of garbage dump.

Some alternative sites have already been identified for future SLF requirements, which are given in Table 15:

Table 15 : Proposed Land Fills Sites in Delhi (in Hectares)

Jaitpur - Tejpur (near the Badarpur Thermal Power Station in South Delhi)	10
Near Goeshalla, Narela, Bawana Road	60
Bhawana Kanjhawala Road (near village Sultanpur Dabas)	40
Kair	4
Purth Khurd	56
Near village Deoral	5

Source : NCRPB, 1999. ISS, 2000

5.4 Treatment of Solid Waste

The appropriate treatment technology for the solid waste is still not adopted by the MCD. The treatment of solid waste reduces the volume and amount of the solid waste and thus reduces the environmental impacts. The practices as of now are only in the pilot project phase and still have to adapt in large-scale operations. MCD had to discontinue the operation of the 150 T/day compost plant of Okhla due to the absence of the market of manure and the high operational cost. However, under the pursuance of the Supreme Courts order the MCD is planning to have the composting plants at some of the SFLs and is also trying to find out the feasibility of the other options such as vermiculture and incineration.

The quantity of Solid waste being treated with different options is given in Table16.

Table16 : Solid Waste Treatment in Delhi

Type of Treatment	Quantity of Waste Treated
Composting	150 t/d (discontinued previously and re-commissioned in June 1996) (proposal of 300 t/d by M/s. Excel Ind. under consideration in 1996)
Vermiculture	Insignificant
Incineration	300 t/d

Source : Compiled from ISS, 2000

6. STATUS OF NOISE

Every person wishes to have calm environment, but the noise pollution has not been given due importance by the authorities and the people. Noise has been notified as a pollutant under the Air (Prevention and Control of pollution) Act, 1981. The main sources of noise pollution are automobiles, jet-engines, construction equipments, loud speakers, industrial activities etc. In recent years public concerns about the rising trends in noise pollution have increased. High noise levels results in auditory fatigue and ultimately leads to deafness. Noise levels at major traffic corridors in Delhi often cross the dB mark. Over half the residential area record noise beyond the acceptable limits of 55 dB.

Ambient noise standards in respect of noise for different categories of area have been notified under the Environment Protection Act, 1986 and the same are given in Table 17..

Table : 17. Noise Standards

Category	Limits in Decibels	
	Days	Nights
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silence Zone	50	40

The noise levels (Leq) at different location monitored during 1995 and 1999 are given in Table 18.

Table 18 : Monitored Noise level in Different Part of Delhi

Location	Leq Levels			
	Day time (1995)	Night (1995)	Day time (1999)	Night (1999)
Ashok Vihar (R)	54	66	71	64
New Friend Colony (R)	53	54	60	53
Cannaught Place (C)	70	68	75.5	75.5
Karol Bagh (C)	73	66.5	74	66
Anand Parvat (I)	74	71	74	61
Wazirpur (I)	74	73	78.5	77
L.N.J.P. Hospital (S.Z)	70	71	65	61
Moolchand Hospital (S.Z.)	64	62	63	61
I.T.O Intersection (T.Z)	75	75	75	72
A.I.I.M.S. Intersection (T.Z.)	75	72.5	75	77

Source : CPCB

From Table 18, it may be observed that the levels of noise in most of the areas are above the prescribed limits.

SECTION-II

The data presented in the previous section clearly demonstrates that Delhi is plagued by all types of pollution. There are two major sets of contributors to pollution (1) increasing population and poor town planning; (2) industries. So far only one approach has been adopted to meet the problem. The approach relates to segregated land use.

Segregated land use in city planning is a typical British legacy but now to be found in Europe and North America as well. It is said to be elitist and utopean for the developing countries. This may be true. However, one needs to appreciate the nature of mixed land use. But noxious and polluting industries should not be allowed at any cost to come up in residential zones.

Delhi is the first city in India to have a Master Plan. The Plan, with a twenty-year perspective (1961-81) envisaged and segregated land use and zonal control. These were demolished over the years by collaborative efforts of local politicians, the individuals, administration and the police. This has already been seen in its naked form first by the invasion of the city by unauthorized colonies and squatters' settlements. Now it is the turn of small industries.

A major source of industrial pollution is the small-scale sector — from small tanneries to tiny electroplating outfits — which use low-grade technology. In most cases these industrial units exist cheek by jowl with residential areas and schools and lead to serious exposures to toxic pollutants in surrounding areas. Controlling pollution from this sector is proving to be extremely difficult. Lax urban regulations means that these industries can mushroom all over the place. Lack of cheap pollution control devices for these units is another problem. Common effluent treatment plants can help but they demand cooperation amongst the polluters who do not want to cooperate because none of them wants to bear the cost of pollution control . Given the highly competitive conditions in which this sector exists, owners like to cut every possible corner to make their profits. In such a situation, there is strong resistance to do anything about pollution. A corrupt administration makes it all the more easy to subvert the statues.

The flauting of zonal regulations and planning control is now being justified by giving a 'humanitarian' shade to it. Howewer, the suffering of the residents of colonies having polluting industries is equally humanitarian problem, sustainable solution lies in decongesting the city by rooting out the industries from residential areas. This needs to be accompanied by strict zoning regulation and control to prevent mixing of industries with residential units. However, the effort to decongest must be accompanied by severely penalizing and punishing those officers of government who are responsible for the flauting of zoning regulations.

Apart from segregated land use method approach, another approach towards checking the pollution problem can be what is often called economist's approach. This approach begins with the assumption that the goal is to reduce industrial pollution to the point where it is compatible with acceptable levels of air and water quality. The idea is not to eliminate it altogether. There are three ways to achieve this: (1) use of cleaner inputs (e.g. cleaner natural gas instead of dirtier coal); (2) cleaner production processes, and (3) treatment (i.e. abatement) of emissions produced. Only the producer knows which one or more of these three approaches is cheaper and more feasible. Neither the judge nor the bureaucrat can or should dictate the manner in which pollution should be abated.

An alternative approach (Gupta, 2000) to reduce industrial pollution is through an emission / effluent tax. Economists have long advocated the use of market-based instruments (MBIs) such as emission taxes to address environmental problems including industrial pollution. The common element among these instruments is that they work through the market and alter the behaviour of economic agents (such as firms) by changing the nature of incentives / disincentives these agents face. This approach is perhaps the most effective way to reach out and alter the myriad of individual decisions mentioned above. For example, an emissions tax levied at a given rate (in rupees per gram of Biological Oxygen Demand discharged), irrespective of the nature of the factory would create the flexibility for the owner to decide the least costly manner in which to reduce pollution. The total tax paid would be equal to the tax-rate per gram of pollutant, times the total emissions. To reduce the tax bill the owner could pick one or more of a wide range of options, e.g. use cleaner fuel, improve maintenance and retrofit emission control devices. All of these measures would fit one of the three categories described above. Under this approach, there would be no need to micro-manage individual decisions. The long arm of the law, the second best approach to the problem may be employed by unposing environmental taxes on final products associated with pollution (such as motor vehicles), taxes on goods that are generally used as inputs into a polluting activity (such as coal or chromium), and taxes on polluting substances contained in inputs (such as sulphur in coal). International experience shows environmental taxes are not difficult to administer, particularly in countries where other taxes are already collected from industries. At least six OECD countries (Canada, France, Japan, Portugal, Sweden and the U.S) use emission fees. Other countries such as Columbia, Poland and China have also successfully used environmental taxes. China has had these in place since 1979 and left India light years behind in this regard as in much else.

In sum, there is lot in the tool kit of economists that can be fruitfully used to address urban industrial pollution which has been tried in various countries, rich and poor. How long can we afford to be a glaring exception and pursue ill-advised judicial/ bureaucratic interventions?

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Appendix - I

Ambient Air Quality (SO_2)

Type	Name	SO2AG87	SO2AG88	SO2AG89	SO2AG90	SO2AG91	SO2AG92
I	Nizamuddin	15.5	10.4	13.0	7.4	12.9	16.9
I	Ashok Vihar	2.9	4.7	5.0	6.6	16.5	17.6
I	Shahzada Bagh	48.0	18.5	9.9	6.6	12.8	29.6
I	Shahadra	16.6	17.5	13.5	25.3	17.3	16.6
R	Janakpuri	10.1	15.9	6.2	6.5	11.8	16.4
R	Siri Fort	6.2	2.3	4.8	8.7	8.4	13.4
R	Sarojini N.Y School	0.0	0.0	0.0	15.3	52.3	12.7
I	Najafgarh (E.S.I.)	0.0	0.0	0.0	32.5	25.5	20.6
R	Town Hall	0.0	0.0	0.0	–30.6	106.1	24.4

Ambient Air Quality (SO_2)

Type	Name	SO2AG93	SO2AG94	SO2AG95	SO2AG96	SO297	SO298
I	Nizamuddin	13.7	16.1	15.9	17.5	17.0	16.0
I	Ashok Vihar	17.7	21.1	17.7	16.2	14.0	15.0
I	Shahzada Bagh	25.4	30.1	26.0	22.5	24.0	23.0
I	Shahadra	22.4	21.3	22.2	19.9	22.0	18.0
R	Janakpuri	15.1	16.1	17.9	17.0	16.0	17.0
R	Siri Fort	16.5	12.5	14.5	15.0	13.0	15.0
R	Sarojini N. Y. School	16.3	23.5	23.4	11.5	10.2	0.0
I	Najafgarh (E.S.I.)	21.5	34.4	30.5	17.4	19.0	0.0
R	Town Hall	30.7	52.8	43.1	22.7	17.5	0.0

Ambient Air Quality (Nox)

Name	NOXAG93 3	NOXAG94 4	NOXAG95 5	NOXAG96 6	NO297	NO298
Nizamuddin	30.1	37.2	37.0	36.4	37.0	35.0
Ashok Vihar	31.0	30.0	28.5	25.6	23.0	21.0
Shahzada Bagh	33.4	37.6	45.3	41.8	45.0	41.0
Shahadra	35.1	29.0	27.6	28.4	28.0	29.0
Janakpuri	37.8	36.0	37.2	36.9	35.0	32.0
Siri Fort	31.8	28.3	28.9	31.5	38.0	27.0
Sarojini N.Y. School	31.7	55.8	57.2	45.9	32.2	0.0
Najafgarh Dispensary (E.S.I.)	25.7	60.0	52.0	40.4	38.0	0.0
Town Hall	51.7	77.7	110.8	75.3	37.7	0.0

Type	Name	NOXAG87	NOXAG88	NOXAG89	NOXAG90	NOXA91	NOXAG92
I	Nizamuddin	23.6	11.6	17.5	15.7	25.2	30.1
I	Ashok Vihar	17.0	26.0	23.4	25.4	31.3	32.8
I	Shahzada Bagh	30.8	28.7	21.2	23.5	25.2	29.2
I	Shahadra	14.6	16.8	15.5	23.2	24.6	34.9
R	Janakpuri	16.6	24.4	18.3	25.8	32.7	31.0
R	Siri Fort	19.9	16.1	15.1	21.1	24.2	24.1
R	Sarojini N.Y. SCHOOL	0.0	0.0	0.0	35.2	66.9	24.1
I	Najafgarh Dispensary (E.S.I.)	0.0	0.0	0.0	42.6	61.2	24.7
R	Town Hall	0.0	0.0	0.0	51.5	108.4	41.0

Ambient Air Quality (SPM)

Type	Name	SPMAG87	SPMAG88	SPMAG89	SPMAG90	SPMAG91	SPMAG92
I	Nizamuddin	452.0	286.0	331.0	294.0	296.0	358.0
I	Ashok Vihar	687.0	310.0	385.0	339.0	259.0	321.0
I	Shahzada Bagh	718.0	413.0	510.0	447.0	373.0	498.0
I	Shahdara	515.0	354.0	361.0	314.0	325.0	364.0
R	Janakpuri	454.0	232.0	322.0	317.0	391.0	372.0
R	Siri Fort	410.0	211.0	328.0	317.0	255.0	351.0
R	Sarojini N.Y. SCHOOL	0.0	0.0	0.0	383.0	336.0	344,0
I	Najafgarh Dispensary (E.S.I.)	0.0	0.0	0.0	527.0	544.0	191.0
R	Town Hall	0.0	0.0	0.0	568.0	728.0	480.0

Ambient Air Quality (SPM)

Name	SPMAG93	SPMAG94	SPMAG95	SPMAG96	SPMG97	SPMG98
Nizamuddin	362.0	443.0	398.0	413.0	382.0	336.0
Ashok Vihar	322.0	340.0	406.0	361.0	327.0	315.0
Shahzada Bagh	421.0	373.0	369.0	393.0	295.0	360.0
Shahdara	383.0	350.0	437.0	446.0	452.0	374.0
Janakpuri	393.0	426.0	422.0	352.0	362.0	332.0
Siri Fort	353.0	331.0	408.0	348.0	388.0	380.0
Sarojini N.Y. SCHOOL	377.0	499.0	308.0	303.0	288.0	0.0
Najafgarh Dispensary (E.S.I.)	622.0	719.0	475.0	527.0	425.0	0.0
Town Hall)	588.0	537.0	472.0	479.0	401.0	0.0

Appendix-II

Status of Ground water in Delhi (Bacteriological Parameters)

	Coliform nos./100 ml	Alipur		Kanjhawalã		Najafgarh		City		Shahadra		Mehrauli	
		TC	FC	TC	TC	FC	TC	FC	FC	TC	FC	TC	FC
1	Absent	23	37	15	27	69	27	43	40	8	31	13	33
2	< 10	6	1	12	23	5	8	3	1	10	1	10	2
3	20-30	2	0	5	3	0	6	0	0	3	0	2	0
4	21-30	4	0	5	11	1	2	0	0	4	1	2	0
5	31-40	1	0	2	3	0	1	0	0	2	0	4	0
6	41-50	2	0	2	3	0	1	0	0	2	0	3	0
7	51-100	0	0	0	1	0		0	0	4	0	1	0
8	>100	0	0	1	4	0	1	0	0	0	0	0	0
9	Total sample	38		42		75		46		33		35	