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Environmental Pollution and Control: A Case Study of Delhi Mega City

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The present paper is an attempt to examine the trend in the level of environmental pollution in Delhi and measures taken to control it. The data have been analyzed from various secondary sources of data. The analysis reveals that rapid population growth continues to be a matter of concern as it has manifold effects, one of the most important being environmental pollution. Densely populated and rapidly growing Delhi mega city is often entombed in a pall of pollution from vehicles, sewage and liquid wastes generated by human settlement and uncontrolled pollution from industries. The recent pollution control measures taken by central government reduced the environmental pollution up to some extent.

KEY WORDS: environment, pollution, control, mega city.

INTRODUCTION

Environmental pollution is one of the serious problems in most of the mega cities of the world, especially in developing countries, which not only experiences a rapid growth of population due to increasing rate of rural urban migration but also industrialization which is accompanied by air, water and vehicular pollution. Exposure to environmental pollution is now an almost an inescapable part of urban life of the world. The phenomenal increase in the population during the last 50 years has led to rapid industrialization and high rate of urbanization, which has created a great deal of

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pressure on its all natural resources. The increase of population has been tending towards alarming situation. If the world population continues to multiply, the impact on environment could be devastating. Though the relationship is complex, population size and growth tend to expand and accelerate these human impacts on the environment. All these in turn lead to an increase in the environmental pollution levels. The WHO Commission on Health and Environment recently concluded its work, identified air pollution as a major environmental health problem deserving high priority for action (WHO, 1992).

Delhi is one of the 10 most polluted cities in the world. In Delhi city the municipal services such as water supply and sanitation, drainage of storm water; treatment and disposal of waste water; management of solid and hazardous wastes; supply of adequate and safe food and housing are all unable to keep pace with urban growth. All these in turn led to an increase in the pollution levels. Also the unplanned location of industries in and around the Delhi mega city followed by improper traffic regulation causes serious pollution problems. However, all these factors together not only lead to deteriorating environmental conditions but also have adverse effects on the health of people. The people in environmental polluted areas are prone to pollution and infected by pollution related diseases. Delhi is perhaps one of the better examples to explain the environmental pollution and measures taken to control it. In light of the above, the present paper is an attempt to examine the trend in the level of air and water pollution in Delhi and measures taken to control it. The data on population have been analyzed from various population censuses of India. The data on pollution was obtained from the Central Pollution Control Board (CPCB) and data on vehicular growth is taken from the Statistical Handbook of Delhi and Compendium of Environment Statistics. Although the available secondary data is not an end itself, it does provide a glimpse of the present scenario of the environmental degradation, its causes and reasons for concern. It provides the necessary base to bring out the magnitude of the problems in a focused way.

POPULATION CHARACTERISTICS OF DELHI

Increase of Delhi Population

According to the provisional results of the Census of India 2001, the population of Delhi on 1st March 2001 is 13.78 millions comprising of 7.57 million males and 6.21 million females growing at the rate of 3.81% per annum during 1991–2001 (Registrar General and Census Commissioner of

India, 2001). Population characteristics of Delhi mega city are presented in Table 1. The data reveals that the population of Delhi had grown from 1.44 to 12.82 millions during 1951–1991, depicting 8.9-fold population over the period. It is evident from table that the population in Delhi mega city more than doubled between 1951 and 1971. Delhi for the first time crossed 5 million mark and thus became the third mega city of India in 1981. The population of Delhi again almost doubled between 1971 and 1991. The annual exponential growth rate of Delhi mega city reveals fluctuations over the decades. The pace of population growth reduced considerably as it fluctuated from 7.26% per annum in 1951 to around 4–5% per annum till 1981 and decline further to less than 4% per annum during 1981–1991 and 5.13% per annum during 1991–2001. The number of persons per square kilometer was very large 7977 in 1991 and 9294 in 2001.

The Population Covered by Basic Services in Delhi

Table 2 shows the population covered by basic services in Delhi. The Census of India data indicates that the city fails to provide basic amenities to this large population, as a result it poses problem of garbage collection and disposal which is one of the reason behind environmental pollution in the city (Registrar General and Census Commissioner of India, 1994).

Industrial Progress in Delhi

Directorate of Economics and Statistics (1997) data shows that there has been steady rise in the number of industrial units from 85 in 1991 to 93

TABLE 1

Population characteristics of Delhi mega city, 1951–1991

Year	Population (in millions)	Average annual exponential growth rate (%)	Ratio of population 1951 population. (1951 = 100)
1951	1.44	7.26	100
1961	2.36	4.96	164
1971	3.65	4.36	254
1981	5.73	4.52	399
1991	8.47	3.85	586
2001	12.82	4.1	890

Source: Census of India, New Delhi, 2001.

TABLE 2**Population covered by basic services, Delhi, 1994**

Area	Percentage population covered by							
	1	2	3	1&2	2&3	1&3	1&2&3	None
Delhi (Total)	79.48	95.78	63.38	76.93	61.56	59.86	58.16	1.54
Municipal Corporation of Delhi (MCD)	83.09	96.56	68.75	80.73	66.85	66.71	64.88	1.02

Note: 1—electricity, 2—safe drinking water, 3—toilet. *Source:* Census of India, Housing Amenities, Occasional Paper No. 5, New Delhi, 1994.

in 1993 and 126 in 1996 due to the better infrastructural and location facilities (Table 3).

VEHICLE GROWTH

With the increasing population, urbanization and industrialization, the transport demand has also increased consequently. There has also been an increase in the number of vehicles to keep pace with the required number of people. The data reveals that the total number of vehicles in Delhi has increased from just 37.4 thousands in 1961 to 2229.6 thousands in 1996. The number of two wheelers has increased from just 12.1 thousands in 1961 to 1741.8 thousands in 1996. In Delhi two wheelers are getting popular due to their economic use. The number of car/jeep increased from 15.1 thousands in 1961 to 633.8 thousands in 1996 followed by goods vehicles, other vehicles, buses and taxis. The two wheelers contributing 66% of the total vehicles in metropolitan cities of Delhi followed by cars and jeeps 24%

TABLE 3**Industrial progress in Delhi, 1990–96**

Year	1991	1992	1993	1994	1995	1996	% growth (1991–96)
Industrial units (in '000')	85	89	93	97	101	126	55.65

Source: Statistical Handbook, NCT of Delhi, 1997.

(Table 4). The environmental effects of fuels like oil and petroleum products are of growing concern owing to increasing consumption levels. The increasing vehicles in Delhi have also increased the vehicular pollution and it accounts for a considerable share of air pollution. Vehicular traffic is the most important source of air pollution in Delhi mega city.

TRENDS IN THE LEVEL OF POLLUTION

The pollution can be broadly categorized as flux type of pollution and sink type of pollution. The former refers to the pollutants dumped into the environment, either to air or in water; while the later is caused by accumulation either in soil or riverbed or also in groundwater. In this paper, however, the study is restricted to air and water pollution.

Air Pollution

The World Health Organization (WHO, 1996) defines air pollution, as “substances put into the air by activity of mankind into concentrations sufficient to cause harmful effects to health, property, crop yield, or to interfere with the enjoyment of property”. According to Bhargava (1995) some of the most important air pollutants are suspended particulate matter (SPM); nitrogen oxides (NO_x); carbon monoxide (CO); lead, sulfur dioxide (SO₂) etc. (Table 5).

According to the Article 48 of constitution of India, the state shall endeavor to protect and improve the environment and to safeguard the forests and wildlife of the country. The main instruments for control of air

TABLE 4

Percentage distribution of total registered motor vehicles in Delhi during 1995 and 1996 (in thousands)

Year	Two wheeler	Car/jeep	Taxis	Buses	Good vehicles	Others	All vehicles
1961	12.1	15.1	2.0	1.3	4.1	2.7	37.4
1971	109.1	61.5	4.1	3.3	15.3	10.8	204.1
1981	36.4	123.6	6.6	8.5	38.1	20.9	561.8
1995*	1617.7	575.8	12.5	26.2	125.1	75.0	2432.3
1996*	1741.8	633.8	13.7	27.9	133.5	59.0	2629.6

Source: Statistical Handbook, NCT of Delhi, 1997 and *Compendium of Environment Statistics, 1999.

TABLE 5**Major sources and health effects of pollutants**

Pollutant	Main source	Health effects
SPM	Ceramic and glass, thermal power	Damage of lungs, may cause bronchitis and asthma
SO ₂	Thermal power, chemicals, ceramics, textiles	Acid rain, damage to lungs, eyes, skin
No _x	Diesel engines, ceramics	Form smog, damage to respiratory system and eye irritation
CO	Two wheelers, engineering	Toxic causes blood poisoning
HC	Two wheelers, ceramics, chemicals	Cancer
Aldehydes	Chemicals	Cancer
Lead	Petrol engines, water pipes, food cans, batteries	Nervous system shows down and brain development is retarded, shows reaction time, reduces attention span
Chromium and nickel	Alloys plating, electronics and fungicide	Cancer
Noise	Industry, traffic	Deafness, irritation and nervousness
Mosquitoes	Stagnant pools	Malaria
Bacteria, worms and virus infections	Infected water	Jaundice, cholera, dysentery, typhoid, diarrhea, polio, worms

Source: Delhi Environmental Status Report: Pollution, Monitoring and Technology Corporation Division, New Delhi, 1995.

and water pollution are the Air (Prevention and Control of Pollution) Act, 1981 and the Environment (Protection) Act, 1986). The Environment (Protection) Act 1986 is implemented through Delhi government and through other relevant agencies such as Pollution Control Boards and Factory Inspectorates in order to reduce levels of suspended particulate matter (SPM); nitrogen oxides (NO_x); carbon monoxide (CO); lead, sulfur dioxide (SO₂) etc. The major impacts have been observed through the following steps taken by the government to control air pollution:

- (i) *Unleaded petrol*: With the gradual reduction of lead content in petrol and finally supply of unleaded petrol for all vehicles from September

- 1998 in the capital city of Delhi, a lethal pollutant from vehicular exhaust has been removed. The lead content in the atmosphere near traffic intersections of Delhi has reduced by more than 60% with this measure.
- (ii) *Sulphur in diesel*: The sulphur content in the diesel supplied in Delhi has been reduced from 0.5% in 1996 to 0.25% in 1997 so as to meet the EURO-II norms.
 - (iii) *Tightening of the vehicular emission norms*: From 1995 new passenger cars were allowed to register only if they were fitted with catalytic converters. Emission norms for such cars were tightened by 50% as compared to 1996 norms. With the recent directions of the Hon'ble Supreme Court, passenger cars (both petrol and diesel) are required to meet at least EURO-I norms in June 1999 and from April 2000 only such vehicles are also permitted by the Supreme Court directions.
 - (iv) *2T oil for two stroke engines*: From 1.04.99, on the recommendations of CPCB, the low smoke 2T oil became effective. To prevent the use of 2T oil in excess of the required quantity, premixed 2T oil dispensers have been installed in all the petrol filling stations of Delhi. Sale of loose 2T oil has also been banned from December 1998.
 - (v) *Phasing of grossly polluting vehicles*: On CPCB's recommendations initially 20 years old vehicles were prohibited from playing from December 1998, followed by phasing out of 17 years old vehicles from November 1998 and 15 years old from December 1998.
 - (vi) The implementation of emission norms and fuel quality specifications effective from 1996, as also phasing out of 15 year old commercial vehicles and leaded petrol in the year 1998 and phasing out of 8 year old commercial vehicles and 15 year old two wheelers from 2000 onwards.

Central Pollution Control Board (1997) data indicates that the quantity of vehicular emissions without measures is estimated to have increased from 2047 thousand tones per day in 1995–1996 to 2459 thousand tones per day in 1998–1999. But the estimated quantity of vehicular emissions with measures has been decreased from 1957 thousand tones per day in 1995–1996 to 1825 thousand tones per day in 1998–1999 (Table 6). However, there are some positive signs noticed in the direction of controlling vehicular pollution by the traffic department along with the Government of the National Capital Region of Delhi. The tightening of norms of emissions both by the industries as well as vehicles has resulted in the falling of the level of harmful gases in the atmosphere.

With the alarming increase in the atmospheric pollution, especially in the Delhi mega city, Government has taken some important initiatives in the recent years. These relate to the progressive tightening of the

TABLE 6
Estimated Vehicular Pollution load in Delhi

Pollutant	Pollution load (000 tones)				% Reduction as compared to 1995–1996
	Without measures		With measures		
	1995–1996	1998–1999	1995–1996	1998–1999	
Carbon monoxide	373	451	351	337	4
Hydrocarbon	121	148	113	115	+2
Nitrogen oxide	208	248	207	182	12
Sulfur dioxide	15	17	15	11	27
Lead	0.259	0.362	0.259	0.007	97
Particulate matter	28	22	28	21	25
Total pollution load	747	897	714	666	
Emission load in t/day	2047	2459	1957	1825	

Source: Central Pollution Control Board, Air Quality Status and Statistics, New Delhi, 1996–1997.

auto-emission norms (1991, 1996, 1998 and 2000) and fuel quality specifications (1996) as recommended by the CPCB. Till early 1994 ambient air quality standards in India were based on 8 hourly average times only. In April 1994, these standards were revised and 24 hourly standards were also prescribed. National ambient air quality standard are prescribed for three distinct areas viz., (i) industrial, (ii) residential, rural and other areas and (iii) sensitive areas. It is evident from table that the major air pollutants show a steady decrease during 1995–1996 to 1998–1999. The percent reduction in 1998–1999 as compared to 1995–1996, has been about 4% in carbon monoxide, 12% in nitrogen oxide, 27% in sulphur dioxide, 97% in lead, and 25% in particulate matter whereas there is a marginal increase of 2% in hydrocarbons (Table 6). Ambient air quality in Delhi is depicted in Table 7. It indicates decreasing trend and reduction in the percentage of sulphur dioxide, nitrogen oxide, SPM and carbon monoxide. The percent reduction in 1998 as compared to 1995, in the most harmful emissions of industry viz., sulphur dioxide's level has fallen down by 16%, SPM by 13% lead by 5% and nitrogen dioxide by 4% in industrial areas. The level of sulphur dioxide has fallen by 4%, nitrogen dioxide by 13%, SPM by 17% and lead

TABLE 7
Ambient air quality in Delhi

Pollutant	1995	1998	% Reduction as compared to 1995
<i>Industrial</i>			
Sulphur dioxide	24.1	20.2	16
Nitrogen dioxide	35.5	34.7	4
SPM	420	36.7	13
Lead	110	105	5
<i>Residential</i>			
Sulphur dioxide	16.5	15.8	4
Nitrogen dioxide	32.5	28.6	13
SPM	409	341	17
Lead	155	95	39
<i>Traffic intersections</i>			
Sulphur dioxide	42	25	40
Nitrogen dioxide	66	63	5
SPM	452	426	6
Lead	335	136	60
Carbon monoxide	5587	5450	3

*All units are in micrograms/cubic meter except for lead, which is a nanogramme/cubic meter.
Source: Central Pollution Control Board, Air Quality Status and Statistics, New Delhi, 1996-1997.

by 39% in residential areas, which is quite significant achievement. The percent reduction during 1995 – 1998 has been about 60% in lead, 40% in sulphur dioxide, 6% in SPM followed by 5% in nitrogen dioxide and 3% in carbon monoxide on traffic intersections. Industries are the second major source of air pollution in Delhi, though like vehicular pollution it is also decreasing. The period between 1971 and 1981 witnessed massive industrialization in various parts of Delhi, including the residential areas. The government at that period of time did not take any measure either to shift such industries from the residential areas or impose strict pollution control measures.

Ambient Air Quality of Delhi in Comparison to WHO Air Quality Guidelines

The primary aim of the ambient air quality standards is to provide a basis for protecting public health from adverse effects of air pollution and

for eliminating and reducing minimum against established guidelines. The ambient air quality as monitored by CPCB during 1999 shows reduction in levels of various air pollutants in ambient air as compared to previous years. The reducing trend was observed with respect to carbon monoxide, nitrogen dioxide and lead in residential areas. But in comparison to WHO air quality guidelines, the levels of suspended particulate matter is more than the double and the levels of lead are much more whereas the levels of sulphur dioxide and nitrogen dioxide are lower.

After having analyzed the trend in the level of air pollution it becomes necessary to discuss the major sources responsible for causing such pollution. The three main sources of air pollution in Delhi are industrial, vehicular and domestic (Table 8). The vehicular emissions cause 72% of air pollution in Delhi, and the number of vehicles on the road growing by 500 a day, its getting worse. At the same time there is a decline in pollution from 56 to 20% due to industrial sources and from 21 to 8% due to domestic sources during 1970–1971 to 2000–2001 respectively.

Water Pollution

Water pollution comes from three main sources: domestic sewage, industrial effluents and runoff from activities such as agriculture. Water pollution from domestic and human wastewater causes many severe water borne diseases. The problem of water pollution due to industries is because of the inadequate measures adapted for effluent treatment than to the intensity of industrial activities. The quantity of sewage and liquid wastes from human settlements and uncontrolled industries generated by Delhi now far exceeds both the city's wastewater treatment capacity and carrying capacity of its sewers. The water quality is affected due to the inadequate availability of basic facilities and rapidly increasing population. The

TABLE 8

Sources of air pollution, Delhi, 1970–2001

Category	1970–1971	1980–1981	1990–1991	2000–2001*
Industrial	56%	40%	29%	20%
Vehicular	23%	42%	63%	72%
Domestic	21%	18%	8%	8%

*The values for 2000–2001 is projected based on the given data.

Source: Central Pollution Control Board, Air Quality Status and Statistics, New Delhi, 1996–1997.

drainage system in Delhi is rather inadequate and badly maintained. It is cited from (Bhargava, 1995) that the rainy season brings with it water-logging due to clogged drains. Consequently, the enormous volume of raw sludge that enters Yamuna has given rise to alarming levels of water pollution. Liquid wastes that do not find their way into waste disposable system lie in stagnant pool, percolating into and contaminating ground water reserves. While the sewage generation is 1700 milliliter per day but the city has capacity to treat only 1270 milliliter per day (MLD), thus the shortfall of 430 MLD goes untreated into the river Yamuna. The only organisms that proliferate in these highly polluted waters are bacteria. Before the Yamuna enters Delhi, 100 milliliters of its water contains about 7500 coliform organisms (principal bacteria) that accompany dissolved and suspended solid wastes. After it receives Delhi's wastewater, the coliform counts sky-rockets to 9 million MPN/100 ml. Indian standards permit upto 5000 organisms/100 ml. Water that enters Yamuna through the drains, about more than 90% of this is domestic wastewater. In fact, the increase in population has resulted in an increase in the generation of wastewater from 967 MLD in 1977 to 1700 MLD in 1993. However, most of this is untreated waste mainly because of the absence of proper sewerage system. There are no sewers and certainly no sewerage treatment facilities in many of the six hundred unauthorized colonies.

It is cited from Chatterjee (2001) that although industrial effluents on the whole contribute only a small percent of the total wastes that are discharged into the Yamuna (contribution of Municipal wastewater is 65% and they are potentially more hazardous than domestic sewage). CPCB has identified 45 significant water-polluting industries in the National Capital Territory (NCT) of Delhi, which together discharge from industrial sources through various drains. It is estimated that at least 50 significantly water-polluting industries are operating in the NCT of Delhi. The problem of haphazard growth is that many industries have been set up in areas which not earmarked for factories and hence dealing with their wastes.

Even there is a great threat to ground water contamination. For disposal of the 4000 metric tons of solid waste generated daily by Delhi's population, an average of 400 grams per capita per day, the sanitary landfill method (SLM) is commonly adopted. Over 60 ha of land at present is under landfill. Out of 20 landfill sites only three at Gazipur (largest one), Bhalasawa and Okhala are active and others are abandoned. The sites being unlined the threat to groundwater contamination is great. In many of the sub-standard housing colonies, wastewater and garbage denied of proper outlets stagnate for long periods slowly and eventually pollute the ground water. Ground water sources in the vicinity of industrial areas are more

prone to contamination, especially, by toxic elements in the absence of adequate sewage system.

For controlling water pollution the water (Prevention and Control of Pollution) Cess Act, 1977 and the water (Prevention and Control of Pollution) Amendment Act 1988 has been enacted. The Environment (Protection) Act 1986 related to water is implemented through the CPCB and the State Pollution Control Boards. The emphasis is being laid on the collection and treatment of wastewater before its disposal on land or on surface waters. For this purpose, a sewage treatment plant with proper collection and conveyance system is being promoted. Promotion of waste minimization techniques to conserve raw material by recovering solvents is encouraged which also leads to reduction of pollution at source. The water (Prevention and Control of Pollution) Amendment Act 1988 have been amended in 1988 to make the provisions more stringent and enabling the Pollution Control Boards to close down industries or to deny essential services such as water and electricity to the polluting industries, if found necessary. The enactment of the Air (Prevention and Control of Pollution) Act and the Environmental Protection Act by the Central Government has forced some of the polluting industries to install pollution control devices. It is expected that these measures would bring down the level of environmental pollution in the near future. It is suggested that, there should be strict implementation of the laws for prevention and control of environmental pollution. However, due to lack of data availability a trend in water pollution could not be analyzed.

SUMMARY AND CONCLUSIONS

Rapid population growth continues to be a matter of concern as it has manifold effects, one of the most important being environmental pollution. With the increasing population, urbanization and industrialization, the transport demand has also increased consequently. Delhi is one of the most polluted cities in the world, caused by vehicular growth and industrial pollution. In order to restore the air quality, Delhi government has taken some measures to such extent as already discussed, and these have helped to reduce the levels of air pollution to a large extent. If such measures are carried out in full swing as the study proves that the days are not far away when pollution in Delhi can be minimized to a great extent. As regards to water pollution, more of wastewater treatment plants be established in accordance with the need of time and heavy penalty be imposed on industries disposing off the wastes into the river. Moreover, the landfills are

to be properly managed to prevent ground water contamination. Since, slums are one of the major sources of water pollution proper measure should be taken to facilitate the slums with sewage facilities. There is now high time for giving top priority to control population and pollution of all types. The government should make special efforts to bring about awareness among the people for a collective action to solve this problem. Only legislation may not be able to protect the environment. All citizens and voluntary associations come forward and work together with environment scientists to protect the environment for present and future generation.

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