Chapter 7
AIR POLLUTION

7.1 SOURCES OF AIR POLLUTION:

The sources of pollutants in the city can be categorized into:

A. Domestic;
B. Industrial;
C. Vehicular;
D. DG Sets;
E. Brick kilns
F. Stone Crushers

Except for the stone crushers, the air pollution is mainly due to fuel consumption for dom estic uses, by industries, vehicles, DG Sets and Brick kilns. The fuels used by different sources of pollution are given below.

Sector	Fuel
Domestic	• LPG • Kerosene • Wood/ Coal • /Cow dung
DG Sets	• Diesel Oil
Industrial	• Coal • Coke • Furnace Oil • Diesel Oil
Vehicular	• Diesel • Petrol
Brick Kilns	• Coal

Details of pollution from these sources are given below.

A. DOMESTIC SOURCES

Considerable amount of population (30% of total city population) of Bhubaneswar is mostly living in slums. People living in slums mostly live in *bastis, juggis and jhopris* and they use kerosene, coal and wood for cooking purposes. However, most of the other population is dependent on LPG (Liquefied Petroleum Gas). The total fuel consumed by the domestic sector is given below:

Coal	:	13.69 T/Day
Wood	:	13.69 T/Day
Cow dung	:	06.84 T/Day
LPG	:	57.0 T /Day
Kerosene	:	47.14 KL/Day

These figures had been arrived at based on the following:

- The total LPG consumption per day for domestic purposes as obtained from primary survey is 57.0 t/day. As this fuel is predominantly used in well to do

households, the entire LPG consumption was distributed grid-wise in the non-slum population. Daily use of LPG is for cooking purposes and hence restricted to 4hrs/day.

- The total kerosene oil consumption for domestic purpose is 47.14 kl/day. This was distributed in the grids with according to the population in that grid. Daily use of LPG is for cooking purposes and hence restricted to 4hrs/day.
- As per the survey conducted for this study, it was found that 70% of the slum dwellers especially that in the outer skirts of the city (in the inner city LPG was used), use firewood, coal and cow dung and the average consumption is 100-150 kg/capita/year. Based on the above, the total consumption of coal, wood, cow dung is 13.69 t/d, 13.69 t/d and 6.84 t/d respectively as given in Annexure 20 . Daily use of wood/cow dung/coal in slums is for about 4 hrs/day.

For the estimation of the pollution load due to burning of fuel following formula is used

$$\textbf{Pollution Load } (X_i) = \text{Fuel Consumption } (F_w) \times \text{Emission Factor } (X_i)$$

Where, (X_i) is the pollutant parameter $_i$ (say SO_2)
(F_w) is the fuel consumed of type fuel (say wood)

The estimated air pollution load due to burning of fuel in domestic sector is given in Table 7.1.

Estimation of pollution load from the domestic sector due to burning of fuel can be calculated using the following formula;

Pollution Load (X_i) = Fuel Consumption (F_w) x Emission Factor (X_j)

Where, $X_i \Rightarrow$ It is the pollution parameter (say SO_2)
$F_w \Rightarrow$ It is the quantity of fuel consumption (say wood)
$X_j \Rightarrow$ It is the emission factor (say wood)

Emission Factor For Different Fuels Used In Domestic Sector

Type of Fuel	Consumption (T/Day)	Emission Factor (Kg/Day)				
		SPM	SO_2	NO_x	HC	CO
Wood/Cow Dung	(F_w)	13.7	0.5	5	1	1
Coal	(F_c)	10	19 (S)	1.5	10	45
Kerosene	(F_k)	3	17 (S)	2.3	0.4	0.25
LPG	(F_{lpg})	0.42	0.02 (S)	1.8	0.17	0.44

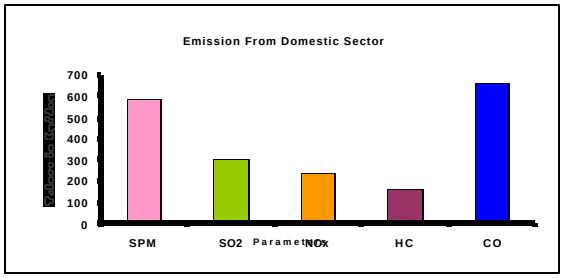
(Emissions Factors from WHO Publication No.62 were used)
Sulpher Content for wood – 0.2, Sulpher Content for Kerosene –0.3, Specific Density of Kerosene – 0.845

Using the above formula the Estimated Air Pollution Load due to burning of fuel in domestic sector is given in Table 7.1.

Table 7.1
Emissions From Domestic Sector

Type of Fuel	Consumption	Pollution Load (Kg/Day)				
		SPM	SO_2	NO_x	HC	CO
Coal	13.69 T/Day	187.55	1.37	68.45	13.69	13.69
Wood	13.69 T/Day	187.55	1.37	68.45	13.69	13.69
Cow Dung	6.84 T/Day	93.71	0.68	34.20	6.84	6.84
Kerosene	47140 L/Day	119.50	203.15	91.62	15.93	9.96
LPG	57.0 T/Day	23.94	0.26	104.88	9.69	25.08
TOTAL		**612.25**	**206.83**	**367.60**	**59.84**	**69.26**

For identifying the spatial distribution of the Air Pollution from domestic sources, the emissions from the domestic sector have distributed on the basis of distribution of slums and non-slum population. The impact of Air Pollution due to burning of domestic fuel viz. coal, wood, cow dung, kerosene and LPG has been categorized into two areas.



Level of Impact	Distance	Prominent Locations
Impact Area I (High)	200 m to the population using wood and cow dung	Slums, Slum Clusters in the city including areas like Sikharchandi, Patia Hadi Sahi, Patia Bhoi Sahi, Rasulgarh, Barmunda, Jokalandi, Ghatikia, Aiginia, Kapil Prasad, Kapileswar, Laxmisagar, Pokhariput, Dumduma Sikharachandi, Patia Hadi Sahi, Patia Bhoi Sahi, Radhakrushna Lane (Near Patia), Rasulgarh Bhoi Sahi, Sabarsahi, Sameigadia, Chakeisiani Tangi Sahi, Pandara, Brahmeswar Patna Bhoi Sahi, Jambeswar Patna (Behera Sahi and Bharati Matha Bhoi Sahi), Kapilaprasad Bhoi Sahi, Nuagaon Khuruda Sahi, Nuagaon Jena Sahi, Kapileswar Bhoi Sahi, Nuagaon Upper Sahi, Pokhariput Bhoi Sahi, Jadupur (A & B), Jadupur Begunia, Puruna Sahi, Odia Sahi, Aiginia Bhoi Sahi, Dumuduma Raghunath Nagar and Bhoi Sahi .
Impact Area II (Medium)	Distributed according to the concentration of non slum population	Other areas under residential and commercial use zones using LPG as fuel.

Refer to Map 10 for details.

B. INDUSTRIAL (AIR) POLLUTION

Bhubaneswar city has 88 no's Industries operating identified by the State Pollution Control Board, Orissa, out of which 16 are Air Polluting and 34 are Water polluting. The details on the location and type of industries in the industrial areas of the city are given in Annexure V. Details of industries operating in different industrial estates (Mancheswar IE, Rasulgarh IE, Chandaka IE and Bhagabanpur IE) and also in other areas are given as Annexure 16. The industries operating in Different Industrial Estates is given in Table 7.2.

Table 7.2
Industries operating in different Industrial Estates

Name & Location of Industrial Estate	Total Area occupied (in Acres)	Total No. of Sheds Allotted	Total Area Allotted (in Acres)	Total No. of Industries Operating				Type of Industries	
				Large	Medium	Small	Total	Air	Water
Rasulgarh IE, Rasulgarh	17	82	1.57	1	1	4	6	3	6
Mancheswar IE, Mancheswar	370	254	167.48	--	22	23	45	3	13
Chandaka IE, Chandaka	940	0	155.74	2	5	3	10	3	6
Bhagawanpur IE, Bhagawanpur	94	0	59.49	--	1	8	9	6	4
Other Areas (other than IE)	--	--	–	--	5	13	18	1	5
TOTAL	**1421**	**334**	**384.28**	**3**	**34**	**51**	**88**	**16**	**34**

The industries listed in Table 7.2 have an impact distance of 2-5 km but not exceeding 7 km. The air pollution from these industries is mainly due to fuel used by them. Industrial Estate wise the type of fuel consumption is given in Table 7.3

Table 7.3
Industrial Estate wise Fuel Consumption in Bhubaneswar Area
(consumption per month)

Type of Fuel	Rasulgarh IE	Mancheswar IE	Chandaka IE	Bhagawanpur IE	Total Fuel Consumption
Furnace oil (klm)	08	13.5	6.0	--	27.5
LPG (tpm)	--	--	13.0	--	13.0
Coal (tpm)	--	392.0	95.0	06	493.0
Kerosene (klm)	--	01.0	–	--	01.0
HSD (klm)	--	18.0	38.0	7.5	38.5
Fire Wood & Others	01	03.0	–	17	21.0
Total	**09**	**427.5**	**152.0**	**30.5**	**594.0**

In industries other than the Industrial Estates OMFED, Bhubaneswar uses 30 Klm furnaces oil as fuel.

As shown above, mainly coal is used as fuel in most of the industries. Based on the above table, the total coal consumption by industries is 493 T/month.

Estimation Of Pollution Load From Industrial Sector

Estimation of pollution load from the Industrial sector due to usage of fuel (firewood, coal, LPG, HSD, Kerosene and furnace Oil) can be made using the following formula;

$$\text{Pollution Load } (X_i) = \text{Fuel Consumption } (F_w) \times \text{Emission Factor } (X_j)$$

Where, $X_i \Rightarrow$ It is the pollution parameter (say SO_2)
$F_w \Rightarrow$ It is the quantity of fuel consumption (say Coal)
$X_j \Rightarrow$ It is the emission factor (say Coal)

Emission Factor For Different Fuels Used In Industrial Sector

Type of Fuel	Consumption (T/Day)	Emission Factor (Kg/Day)				
		SPM	SO_2	NO_x	HC	CO
Lignite Coal	$F_{Lig\ coal}$	3.5 (A)	15 (S)	3	0.5	1
Anthracite Coal	$F_{Anth\ coal}$	1 (A)	19 (S)	5	0.1	3
Bituminous Coal	$F_{Bitu\ coal}$	6.5 (A)	19 (S)	7.5	0.5	1
Fuel Oil Residual (Furnace Oil)	$F_{Fuel\ oil}$	2.87	19 (S)	7.5	0.37	0.52
Oil distillate (HSD / Kerosene)	F_{Oil}	2.13	20.1 (S)	7.5	0.41	0.59
Liquified Petroleum Gas	F_{LPG}	0.38	0.02 (S)	2.6	0.065	0.35
Natural Gas	$F_{Natural\ Gas}$	0.34	20 (S)	3.6	0.058	0.32

(Emissions Factors from WHO Publication No.62 were used)
where A – It is the percentage ash content of combustible by weight.
S – It is the percentage sulphur content of combustible by weight.
Ash Content of Lignite Coal – 0.4, Ash Content of Anthracite Coal – 0.4, Ash Content of Bituminous Coal – 0.4, Sulpher Content for Coal – 0.005, Sulpher Content for Fuel Oil – 0.02,, Sulpher Content for Oil distilate – 0.001, Sulpher Content for LPG – 0.001,

Using the above formula the estimated Air Pollution Load due to burning of fuel in Industrial Sector is given in Table 7.4.

Table 7.4
Emissions From Industrial Sector

Type of Fuel	Consumption		Pollution Load (kg/day)				
	Unit/month	T/Day	SPM	SO_2	NOx	HC	CO
Fire Wood (kg)	17	0.7	9.59	0.35	3.5	0.7	0.7
Coal (t)	493	16.4	3731.0	186.96	123.00	8.20	16.40
LPG (t)	13	0.43	0.1634	$0.86x10^{-5}$	1.118	0.028	0.150
HSD (kl)	38.5	2.11	4.49	0.042	15.82	0.86	1.24
Kerosene (kl)	1.0	0.33	0.70	0.006	2.475	0.135	0.194
Furnace Oil (kl)	57.5	1.91	5.48	0.725	14.325	0.706	0.993
TOTAL			**3751.423**	**188.083**	**160.238**	**10.629**	**19.677**

The major pollutants from industrial sector are SPM & NOx. The quantity of SPM generated is about 3.73 T/Day and NOx of 0.18 T/Day because of coal and coke by the industries. By stopping the uses of coal and adopting natural gas can bring down the industrial air pollution load considerable.

Industrial Air Pollution Map

Considering the air pollution potential of Industries and the meteorological conditions a distance of 2 km has been taken for 'high' risk and a distance of 5 km has been taken for 'medium' risk. The impact of air pollution due to emissions from industries has been categorized into two areas.

Level of Impact	Impact Distance	Prominent Locations
Impact Area I	2 km from industries	Chandrasekharpur, Patharagadia, Patia, Damana, Sikhrachandi, Gadakana, Sainik School Area, Mancheswar, Pandara, Bhagabanpur, Patrapada, Bijipur, Tamando, Subudhipur, Kalinga Nagar, Sankarpur and Dumuduma area.
Impact Area II	2-5 km from industries	Bharatpur, Sundarpur, Andharua, Malipada, Sampur, Ghatikia and Core area of the City

These zones are shown in Map 7.

C. VEHICULAR (AIR) P0LLUTION

The vehicular emissions are one of the major sources of Air Pollution affecting the urban population in Bhubaneswar. Unlike Industrial Emissions, Vehicular pollutants are released at ground level and hence the impact on recipient population will be more. The Annual vehicular growth in the city is presented in the Table 7.5. With such high growth, the impact of the air pollution from vehicular growth would be tremendous.

Table - 7.5
Annual Vehicular Growth In Bhubaneswar

Year	Total Vehicles In The City	Growth Rate (%)
1987-88	7735	--
1988-89	9079	17.37
1989-90	8586	-5.43
1990-91	11051	28.70
1991-92	6991	-36.73
1992-93	7103	1.60
1993-94	8329	17.26
1994-95	10743	28.98

1995-96	12848	19.54
1996-97	14712	14.50
1997-98	16526	12.33
1999-00	27033	57.44
2000-01	25543	-5.51
2001-02	26244	2.74

There is no specific data available regarding the fuel consumption by the vehicles plying in the city. The only data available was the number of registered vehicles for the Bhubaneswar City.

The total number of vehicles in Bhubaneswar District has grown at a tremendous rate of 39 % during 1994 to 2000 and is presented in the table 7.6. The goods HCVs have grown alarmingly by 47%.

Table 7.6
Mode-Wise Vehicular Growth In Bhubaneswar District

Category	1994	2001	% Increase
Cars	540	1893	28
2 Wheelers	8773	20521	43
3 Wheelers & Taxis	320	2045	15
Buses	58	43	–
Goods HCVs	339	718	47
Goods LCVs	147	585	25
TOTAL	**10177**	**20805**	**39.43**

Traffic census on the main roads network covering the major cordon points and the major intersections within the city was carried out to find out the number of various categories of vehicles entering the city from different directions and plying on the road. The number of vehicles in each mode (passenger cars, trucks, busses, 2 wheeler, 3 wheelers) was counted for 24 hrs on a normal working day (1st August, 2002). The following steps were followed to find out the pollution load from vehicles and vehicular pollution areas.

Step I : Link wise vehicles were distributed in each grid of 1 sq km.

Step II : Link wise equivalent passenger car units were calculated using standards as at Table 6.12.

Step III : Link wise lengths and width of the roads were measured in km.

Step IV : Using the design service capacity standards and the road width the congestion was calculated.

Step V : Pollution load was estimated fro each link and vehicular pollution areas identified.

Details including calculations used on the estimation of vehicular pollution load are given in Annexure – VI.

The total number of vehicles estimated in Bhubaneswar up to 2002 is 2 lakhs 9 thousand and six hundred ninety three. Total nos of cars/Taxis, 2 wheelers, 3 wheelers, Buses, Goods HCVs and Goods LCVs are found to be 2 lakhs five thousand and two hundred fifty eight. Detail breakup is given in Table 7.7.

Table 7.7
Mode Wise Selected Vehicles In Bhubaneswar

Sl.	Type of Vehicle	No. of Vehicles
1	Cars/Taxis	19,414
2	2 Wheelers	1,70,004
3	3 Wheelers	5,490
4	Buses	949
5	Goods HCVs	5,575
6	Goods LCVs	3,826
	TOTAL	**2,05,258**

Vehicular Pollution Load

The pollution load on each road link was calculated considering the following formula:

$$\text{Pollution Load } (X_i) = \text{No. of Vehicle } (T_n) \times \text{Emission Factor } (X_i) \times \text{Deterioration Factor } (T_{0\text{-}5\ year}) \times \text{Length of the road in the grid } (G_m) \times \text{Intermediate road links } (R_l)$$

Where (X_i) is the pollutant parameter
(T_n) is the mode say truck 2,000 in number
$(T_{0\text{-}5\ year})$ is the deterioration factor of trucks in 5 years
(G_m) is the grid number of the road link $_m$
(R_l) is the factor representing intermediate road density in the grids G_m

Emissions from Vehicles in Bhubaneswar City are presented in the Table 7.8.

Table 7.8
Emissions From Vehicles In Bhubaneswar City

Type of vehicle	Deterioration Factor*					Emission Factor (g/km)*					Pollution Load (T/Day)				
	SPM	SO_2**	NO_x	HC	CO	SPM	SO_2**	NO_x	HC	CO	SPM	SO_2**	NO_x	HC	CO
Cars/taxis	1.28	1	1	1	1.14	0.05	0.018	1.1	0.8	8.6	0.02	0.075	0.31	0.09	0.56
Jeeps	1.28	1	1	1	1.14	0.05	0.018	1.1	0.8	8.6	0.01	0.001	0.03	1.05	1.06
2 wheelers	1.3	1	1.3	1.3	1.3	0.1	0.002	0.06	3.3	4.0	0.05	0.001	0.43	1.01	1.64
3 Wheelers	1.7	1	1.7	1.7	1.14	8.6	0.002	0.09	7.0	8.6	0.03	0.096	0.94	0.05	0.17
Buses	1.355	1	1	1	1.18	1.6	0.15	16.8	1.21	4.5	0.11	0.096	0.12	0.23	0.97
Trucks/tractors	1.595	1	1	1	1.33	0.8	0.15	1.21	1.21	4.5	0.19	0.081	0.68	0.19	0.35
TOTAL											**0.41**	**0.35**	**2.508**	**2.62**	**4.75**

** Deterioration & Emission factors data taken from CPCB Publication (1998) ** Deterioration factor for SO_2 assumed.*
**** Calculated using emission factors data taken from TERI Report (1998)* ***considering sulphur content in Diesel as 0.05%***

Vehicular Load

The vehicular load in Bhubaneswar is categorized into “High load”, “Medium load” and “Low load” based on PCUs as below.

Categories	PCUs	Prominent Stretches	Road Category
High	2000-3000	Rasulgarh SQ ⇔ Bomikhal SQ Bomikhal SQ ⇔ Jharpada SQ Jharpada SQ ⇔ Kalpana SQ Kalpana SQ ⇔ Museum SQ	NH – 203
		Rasulgarh SQ ⇔ Vani Vihar SQ Vanivihar SQ ⇔ Acharya Vihar SQ Acharyavihar SQ ⇔ Jayadev Vihar SQ Jayadev Vihar SQ ⇔ CRP SQ CRP SQ ⇔ Khandagiri SQ Khandagiri SQ ⇔ Tamando SQ	NH – 5
Medium	1000-2000	Vani Vihar SQ ⇔ Master Canteen SQ ⇔ Rajmahal SQ Achar Vihar SQ ⇔ AG SQ Jayadev Vihar SQ ⇔ Power House SQ ⇔ Rajbhawan SQ Baramunda SQ ⇔ Siripur SQ Khandagiri SQ ⇔ Gandamunda SQ Rajbhawan SQ ⇔ AG SQ Siripur SQ ⇔ Rajbhawan SQ Ravi Talkies SQ ⇔ Garage SQ Garage SQ ⇔ Uttara SQ	Internal City Roads
Low	Less than 1000	Other stretches	Internal City Roads

The vehicular load is shown on Map 8.

Traffic Congestion

The congested stretches in Bhubaneswar are categorized into 'Highly Congested Stretches'; 'Congested' and 'Smoothly Flowing' stretches as below:

Categories	Congestion Level	Prominent Stretches
Highly Congested	> 1.75 (≥75% of the DSC)	Rasulgarh SQ ⇔ Bomikhal SQ ⇔ Jharpada SQ ⇔ Kalpana SQ ⇔ Museum SQ
Congested	1.00-1.75 (> 10% of the DSC)	Vani Vihar SQ ⇔ Rupali SQ ⇔ Ram Mandir SQ ⇔ Master Canteen SQ ⇔ Rajmahal SQ Acharya Vihar SQ ⇔ HUDCO SQ ⇔ PMG SQ ⇔ AG SQ ⇔ Hospital SQ
Smooth Flowing	< 1.00 (≤10% of the DSC)	Rasulgarh SQ ⇔ Vani Vihar SQ ⇔ Acharya Vihar SQ ⇔ Jayadev Vihar SQ ⇔ CRP SQ ⇔ Baramunda SQ ⇔ Khandagiri SQ ⇔ Tamando SQ ⇔ Khandagiri SQ ⇔ Gangamunda SQ Baramunda SQ ⇔ Siripur SQ Jayadev Vihar SQ ⇔ Power House SQ Gopabandhu SQ ⇔ Rajbhawan SQ CRP SQ ⇔ Power House SQ

The congested stretches of Bhubaneswar are shown in Map 9.

Vehicular Pollution:

The total pollution load from vehicles in Bhubaneswar City is 10.63T/Day. Based on pollution load, considering the number of vehicles and the congested stretches, the road stretches of the city are categorized into 'highly polluted', 'medium polluted' and 'moderately polluted'.

Overlaying the congestion map and the link-wise emission load map and providing a buffer of 150 m to the 'highly polluted stretches' and a buffer of 100 m to the "medium polluted stretches" and 50 m to the "moderate polluted stretches", the areas prone to vehicular pollution are identified. Map 10 shows the vehicular emission loads from each road link.

D. DG SETS

Due to power break downs of 1hour daily; a number of DG Sets are used in Bhubaneswar City. Based on a detailed survey carried out, it is estimated that about 8,946 DG Sets operate in the city. As per primary survey, the fuel consumed by the DG Sets by different sectors and the average consumption of diesel varies as per the capacity of the generators. The number of DG Sets, hours of operation and the total fuel consumed are given in Table 7.9.

Table 7.9
Number, Capacities, Hrs Of Operation And Fuel Consumed By Generators

Land Use	Hrs of Operation (hr/day)	Number of generator	Capacity of generators (KVA)	Average consumption of fuel (ltr/Dg set/day)	Fuel (Diesel) consumed (ltr/day)
Residential	1	4,500	5-10	1-2	9,000
Commercial (shops)	1	4,000	5-62	1-2	6,000
Industry	1	80	5-625	2-3	200
Others (Hotels, Cinemas,	1	366	5-800	2-3	915

Land Use	Hrs of Operation (hr/day)	Number of generator	Capacity of generators (KVA)	Average consumption of fuel (ltr/Dg set/day)	Fuel (Diesel) consumed (ltr/day)
Hospitals)					
TOTAL		8,946			16,115

From the above table, the total diesel consumed by DG Sets operating in the city is 16.11 kl/day. For the estimation of the pollution load, the following formula is used: The estimated emissions form DG Sets are given in Table 7.10.

Pollution Load (X_i)	=	Fuel Consumption (F_d)	X	Emission Factor (X_i)

Where, **(X_i)** is the pollutant parameter i (say SO_2)
(F_d) is the fuel consumed of type fuel (say diesel)

Table 7.10
Emission from DG Sets

Type of Fuel	Consumption (L/day)	Pollution Load (kg/day)				
		SPM	SO_2	NOx	HC	CO
Residential	9,000	18	81	54	27	36
Commercial (Shops)	6,000	12	54	36	18	24
Industry	200	0.4	1.8	1.2	0.6	0.8
Others (Hotels, Cinemas, Hospitals)	915	1.83	8.23	5.49	2.74	3.66
TOTAL	**16.115**	**32.23**	**145.03**	**96.69**	**48.34**	**64.46**

Note: Sulphur Content of diesel – 0.05%; Emission factors from WHO Publication No. 62 were used.

For identifying the spatial distribution of the air pollution from the DG Sets, the DG Sets have been distributed throughout the city based on the primary survey and considering the land use, i.e. location of the shops, markets, hospitals and the institutions using the DG Sets. For the residential areas, the emissions have been distributed on the basis of concentration of slums and non-slum population in 1 km^2 grid as explained in Chapter 3. The slum clusters have been marked as areas with less impact, as they do not use DG Sets. The impact of air pollution due to DG Sets emissions have been categorized into two areas and are shown in Map 11.

Level of Impact	Impact Distance	Area
Impact Area I	150 m to the commercial establishments, hospitals, institutions and very densely populated	Nayapalli, Chandrasekharpur, Sahid Nagar, Bapujee Nagar, Old Town, Unit – IX, CRP Square, Ashok Nagar, Vani Vihar, PMG Square, Power House Junction
Impact Area II	Distributed according to the concentration of residential areas (non slum population)	Residential areas in Unit 1, Nalco Nagar, Arjun Nagar,

E. BRICK KILNS

Apart from the above sources number of Brick Kilns are established mainly in the low line areas of the Kuakhai River and Daya. They are catering to the requirements of Bhubaneswar City. Presently about 45 of them are operating within the city having no pollution control device. List of the Brick Kilns who applied for NOC from the Board is given in Annexure

The Government of Orissa, Department of Science & Technology and Environment, vide memo no ENV-I-4/87/STE/18775 dated 26/10/87 have approved the following siting criteria for Brick Kilns, Lime Kilns and Coal Briquette units. The siting criteria for the establishment of the brick kiln are:

1. Such industries should not be established on prime agricultural lands and forest lands
2. They must be located at least ½ km away from the National and State highways high tide lines, flood plains, villages and small settlements and 2 kms away from the out skirts of small towns and population of 50, 000 or less and 5 kms away from the out skirts of large towns of population more than 50, 000.
3. Each unit should be atleast 1 km away from another such unit.

Observations on Brick kilns in Bhubaneswar:

1. The brick kilns are mostly concentrated on the low lying areas of the River Khuakhai. A few of them are also located along the Puri –Cuttack road.

2. Out of the 21 brick kilns, 12 of them fall within 0.5 km from another such unit.
3. As per the survey conducted, it was found out 12-15 brick kilns were operating and had fixed chimney kiln.
4. The kilns were of continuous type in which firing was done continuously, green bricks being put into one part of the kiln and fired bricks withdrawn from another end. Fuel is fed continuously at a constant rate and coal and firewood is the main fuel used.
5. The average depth of the brick kiln were in the range of 2.3-2.6 m. and the length of the kilns varied from 60m - 40m and breadth varied from 6m - 10 m.
6. The production capacity varies from 3-5 lacs per round or 10,000–25,000 per day.
7. From the survey it was found that the 100-120 kg of coal/fuel per 1000 bricks.

Thus average fuel consumed by a single brick kiln: 100 kg x 17,500 =1750 t/day

Estimation Of Pollution Load From a Brick Kiln

Estimation of pollution load from a single brick kiln due to usage of coal can be made using the following formula;

$$\textbf{Pollution Load } (X_i) = \textbf{Fuel Consumption } (F_w) \times \textbf{Emission Factor } (X_j)$$

Where, $X_i \Rightarrow$ It is the pollution parameter (say SO_2)
$F_w \Rightarrow$ It is the quantity of fuel consumption (say Coal)
$X_j \Rightarrow$ It is the emission factor (say Coal)

The emission factor for SPM, SO_2, NOx, HC and CO for all the type of fuels used in the industrial sector is used for the estimation of the pollution load. Using the above formula the estimated Air Pollution Load due to burning of coal from a brick kilns is given in Table 7.11.

Table 7.11
Emissions From Brick Kiln

Type of Fuel	Fuel Consumption	Pollution Load (kg/day)				
		SPM	SO_2	NOx	HC	CO
Coal (t)	1,750 t/d	398125.00	19950.00	13125.00	875.00	1750.00

The major pollutants from this sector are SPM NOx. The quantity of SPM generated is about 398 T/Day and NOx of 19 T/Day. By stopping the uses of coal and adopting natural gas can bring down the industrial air pollution load considerable.

Brick kiln Air Pollution Map

The emissions from the brick kilns is high during the charging phase which occurs for about 10-15 minutes and thick black smoke is emitted during this time. For the remaining period, generally gray smoke is observed. The maximum concentration of the particle size is above 5 microns. Hence the dispersion of the dust particles varies from 200m to 1000m.

Considering the air pollution potential of Industries and the meteorological conditions a distance of 500 m has been taken for 'high' risk and a distance of 1 km has been taken for 'medium' risk. The impact of air pollution due to emissions from industries has been categorized into two areas.

Level of Impact	Impact Distance	Prominent Locations
Impact Area I	500 m from brick kilns	Banks of Kuakhai River, Uttarasasan, Pupasasan,
Impact Area II	1 km from brick kilns	Mancheswar, Gada Gopi Prasad, Rasulgargh, Lakshmi sagai, Baragada.

These zones are shown in Map 7.

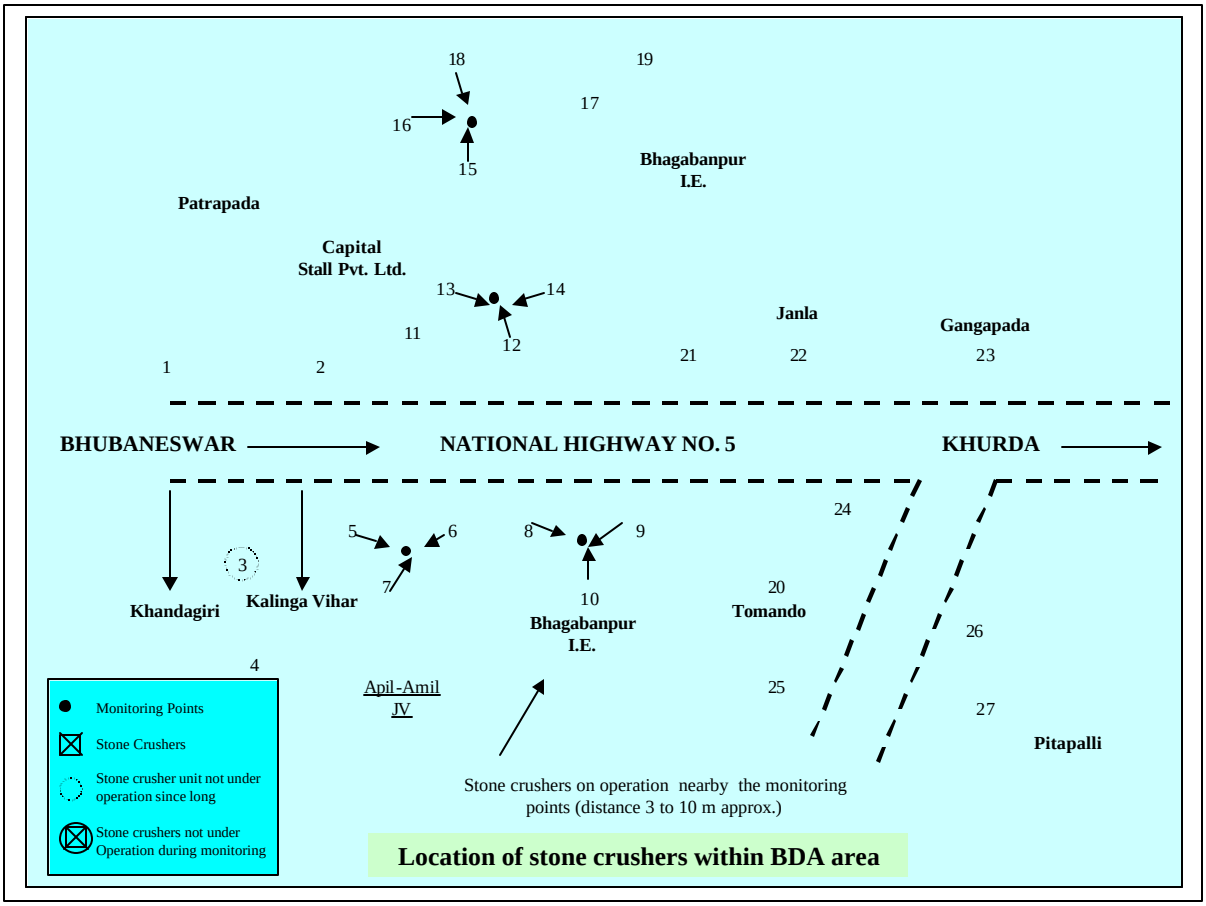
F. STONE CRUSHERS

Apart from these sources of air pollution there are about 19 stone crushers operating within the city. Detail list of the Stone Crushers are given at Annexure 17. Stone crushers are concentrated around the National Highway no 05, which traverses the city. The schematic diagram of the locations of the stone crushers is shown in the fig ---- and the Existing Industries Map.

The Government of Orissa, Department of Science & Technology and Environment, vide memo no ENV-I-4/87/STE/18775 dated 26/10/87 have approved the following siting criteria for the establishment of stone crushers. The siting criteria for the establishment of the stone crushers are:

1. No stone crushers should be allowed within 1km of a town or a village
2. No stone crushers will be located within ½ km from National and State highways
3. Distance between two stone crushers units should be at least ½ km apart.

The EPA Notification No. GSR 742 (E) dated 30th August, 19990 & SO (E) dated 31st December, 1990 have laid down the following standards for SPM in Stone crushers units.



The standards consist of two parts:

1. Implementation of the following pollution control measures:
   - Dust containment cum suppression system for the equipment
   - Construction of wind breaking walls
   - Construction of the metalled roads within premises
   - Regular cleaning and wetting of the ground within the premises
   - Growing of a green belt along the periphery

2. Quantities Standard for the SPM
   - The suspended particulate matter measure between 3 to 10 m from any process equipment of a stone crushing unit shall not exceed 600 µg/m$^{3.}$

Table 7.12
Particulate Emission from a Crusher (crushing capacity 500 MT/day)

S .No	Dry crushing operation	Number of stone crushers using different types of process	Crushing capacity (t)
1.	Primary crushing	01	1000
2.	Secondary crushing screening	08	1610
3.	Tertiary crushing screening	06	332.5

4.	Recrushing & screening	01	95
5.	Fines Mills	10	321.1
TOTAL			**3358.0**

Observations on Stone crushers in Bhubaneswar:

1. The stones crushers are mainly found along the NH-5 (Howrah- Chennai) near Baghwanpur Industrial Estate and Tomando area.

2. The rocks required for crushing are brought away from the city and are further crushed. The stone crushers are involved from primary crushing to recrushing and screening. The process includes crushing, regrinding and removal of fines.

3. Most of the stone crushers units use only jaw crushers that do not have any pollution control device.

4. Out of the operating 19 stone crushers, 2 can be categorized as large with the production capacity of more than 1000 t/day, 7 can be categorized as medium with the production capacity of more than 500-1000 t/day and 10 can be categorized as small with less than 500 t/day.

5. The crushed products are stored in open at the work area. The city falls in the leeward direction.

Estimation Of Pollution Load From Stone Crushers

The EPA (Environmental Protection Agency, USA) emission factors for dust generation in the rock crushing is used for estimation of the pollution (dust) load. The Particulate Emission factors from a dry crushing stone cluster operation is given in Table 7.13.

Table 7.13
Particulate Emission from a Crusher (crushing capacity 500 MT/day)

S .No	Type of Process	EPA emission factors		
	Dry crushing operation	Uncontrolled Total Kg/MT	Settled out in and in process	Suspended dust emission (kg/MT)
1.	Primary crushing	0.25	0.20	0.05
2.	Secondary crushing screening	0.75	0.45	0.30
3.	Tertiary crushing screening	3.00	1.20	1.80
4.	Recrushing & screening	2.50	1.25	1.25
5.	Fines Mills	3.00	0.75	2.25

For Bhubaneswar only suspended dust emission is calculated using the formula:

Pollution Load (X_i) = Crushing capacity (C_c) x Emission Factor (X_j)

Where, $X_i \Rightarrow$ It is the pollution parameter (say SPM) in MT
$F_w \Rightarrow$ Crushing Capacity
$X_j \Rightarrow$ It is the EPA emission factor (say SPM)

Table 7.14
Particulate Emission from a Crusher (crushing capacity 500 MT/day)

S .No	Dry crushing operation	Crushing capacity (t)	Suspended dust emission (kg/MT)	Estimated Pollution load (t/day) (SPM)
1.	Primary crushing	1000	0.05	722.48
2.	Secondary crushing screening	1610	0.30	50.0
3.	Tertiary crushing screening	332.5	1.80	118.75
4.	Recrushing & screening	95	1.25	483.0
5.	Fines Mills	321.1	2.25	598.50
	Total	**3358.0**		**1869.73**

The major pollutants from industrial sector are SPM. The quantity of SPM generated is about 1869 T/Day.

Stone Crushers Air Pollution Map

The dust particles emitted during the crushing operation of the stone crushers varies in size. Although most of them are bigger in size (greater than 10 microns), there are finer particles of less than 1 micron. Considering the variation of the size of the dust particles and the meteorological conditions, a distance of 200 m has been taken for 'high' risk and a distance of 2 km has been taken for 'medium' risk.

The impact of air pollution due to emissions from stone crushers has been categorized into two areas.

Level of Impact	Impact Distance	Prominent Locations
Impact Area I	200 m from brick kilns	Bhagwanpur, Tamand, Pratappara, Sankarpur, Subhudhipur, Bijipur, Damodarpur
Impact Area II	2km from brick kilns	Sijua, Begunia, Jagmar, Ghatika, Sampur, Baramanuda, Khnadagiri & Udaigiri, Naypalli, IRC villagr

G. NATURAL SOURCE

The topsoil of Bhubaneswar consists of hard laterite in the North and Western part. Its origin seems to be influenced by the topography and the bedrock characteristics of the origin. But the Eastern and Southern part consist of alluvial soil formed by the deposition of rivers like Daya, Kuakhai and Bhargavi. The soil dust becomes air borne easily. Dust storms are very common during May-June. The major natural sources of air pollution contributing to SPM are:

1. Open areas not covered with grass of vegetation
2. Fallow agriculture fields – due to changed agricultural practices, fields remain fallow for substantial period from March/April to the next 4 months.
3. Sand from the bed of river Daya, Kuakhai and Bhargavi.

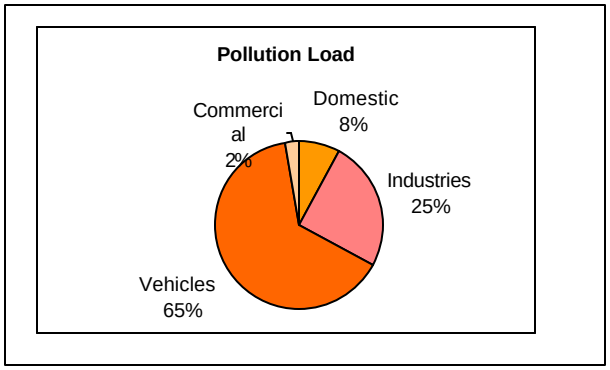
6.2 AIR POLLUTION IN BHUBANESWAR

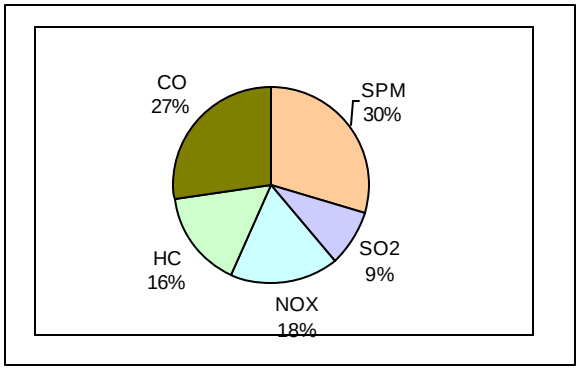
The Total Air Pollution in Bhubaneswar City from the Domestic Sources, Industrial Sources, Vehicular Sources and DG Sets represented by SPM, SO_2, NOx, HC and CO is 16.5 T/day as per break up details given in Table 7.15.

Table 7.15
Total Emission Load (Ton Per Day)

S. No	Sectors	Pollution Load					
		SPM	SO_2	NO_X	HC	CO	TOTAL
1.	Domestic	0.61	0.21	0.37	0.06	0.07	1.32
2.	Industries	3.75	0.19	0.16	0.01	0.02	4.13
3.	Vehicles	0.41	0.35	2.51	2.62	4.75	10.64
4.	DG Sets	0.03	0.15	0.1	0.05	0.06	0.39
5.	***Sub-total (1+4)***	***4.8***	***0.9***	***3.14***	***2.74***	***4.9***	**16.48**

Vehicular Sector is the major contributor to the total pollution load in the city. CO and NOx from vehicular sources is an important parameter as carbon content of these emissions can have harmful effect. The total pollution load including SPM, SO_2, CO, NOx and HC is **16. 48** t/day out of which 65 % is contributed by vehicular sector, 25 % is contributed by industry, 8 % is contributed by domestic, followed by 2 % by D.G. Sets.





SPM and NOx are the major pollution parameters in the city. Industries using coal is the major contributor (3.75 t/d) for high SPM followed by the domestic (0.61 t/d) and the vehicular (0.41 t/d) sectors. Vehicles are the major source of the NOx, HC and CO, which has the maximum contribution to the pollution load in the city. Thus vehicular sector is the highest contributor to the total pollution load.

Apart from the domestic, vehicular, industrial and commercial sectors, a number of brick kilns using coal/wood as fuel are operating within the city. Also, 21 stone crushers using dry crushing operation are operating within the city. Their contribution to the total pollution load in the city changes composition of the pollution load from various sectors. Table 7.16 below shows the pollution load from all the sectors viz. domestic, vehicular, industrial commercial sectors and stone crushers and brick kilns.

Table 7.16
Total Emission Load (Ton Per Day)

S. No	Sectors	Pollution Load					
		SPM	SO_2	NO_X	HC	CO	TOTAL
1.	Domestic	0.61	0.21	0.37	0.06	0.07	1.32
2.	Industries	3.75	0.19	0.16	0.01	0.02	4.13
3.	Vehicles	0.41	0.35	2.51	2.62	4.75	10.64
4.	DG Sets	0.03	0.15	0.1	0.05	0.06	0.39
5.	***Sub-total (1+4)***	***4.8***	***0.9***	***3.14***	***2.74***	***4.9***	**16.48**
6.	Brick Kiln	398.12	19.95	13.12	0.87	1.75	433.81
7.	Stone crushers	1869.73	-	-	-	-	1869.73
8.	***Sub-total (6+7))***	***2267.85***	**19.95**	**13.12**	**0.87**	**1.75**	2303.54
	TOTAL (5+8))	**2273.00**	**20.85**	**16.26**	**3.61**	**6.65**	**2320.02**

Considering the stone crushers and the brick kilns other than the domestic, commercial, vehichular and the DG sets, the total pollution load including SPM, SO_2, CO, NO_x and HC is 2.32 Mt/day of which 98 % is contributed by stone crushers, followed by brick kilns. However, if the stone crushers are shifted out from the city, brick kilns will turn out to be the major contributors of pollution in Bhubaneswar with about 99 % contribution.

Stone crushers are the single largest contributor of SPM with an emission of 1.87 Mt/day followed by brick kilns sources with 0.4 Mt/day. However, about 2.23 Mt/day of PM can be avoided if the stone crushers and the brick kilns are shifted out from the city. It they are shifted out from city then industries using coal is the major contributor (3.75 t/d) for high SPM followed by the domestic (0.61 t/d) and the vehicular (0.41 t/d).

Presently, Brick kiln is the highest contributor of $S0_2$ with an emission of 19.95 t/day followed by vehicles with 0.35 t/day. However, if the brick kilns are supplied with natural gas and stop using coal, vehicles will be the highest contributors of $S0_2$ (0.35 t/day). Vehicles also are the highest contributors interms of CO and HC. The high load of CO (4.75 t/day) is attributed to two & three wheelers (1.37 t/day) followed by trucks (0.6 t/day) and buses (0.5 t/day).

The air pollution impact areas, demarcated based on estimated pollution loads from various sources, are shown in Map 12.

6.3 EXISTING AIR QUALITY

A. Air Quality Standards

The national ambient air quality standards as prescribed by the Central Pollution Control Board for sensitive zones, are applicable in the city is given in Table 7.17. (Ref Table 7.15 Based on the

observed values, the Air Quality is categorized into Critical, High, Moderate and Low as shown in Table 7.18.

Table 7.17
National Ambient Air Quality Standards

Pollutant	Time Weighted average	Industrial area	Residential, Rural and other area	Sensitive area
Sulphur dioxide (SO_2)	Annual 24 hours	80 120	60 80	15 30
Oxides of Nitrogen (NO_x)	Annual 24 hours	80 120	60 80	15 30
Suspended Particulate Matter (SPM)	Annual 24 hours	360 500	140 200	70 100
Respirable Particulate Matter (RPM)	Annual 24 hours	120 150	60 100	50 75
Lead (Pb)	Annual 24 hours	1.0 1.5	0.75 1.0	0.5 0.75
Carbon monoxide (CO)	8 hours 1 hour	5.0 10.0	2.0 4.0	1.0 2.0
Ammonia	Daily Average (Sample duration 24Hours)	400		
	Annual Avg of 104 sample (2 samples drawn every week)	100		

All values are expressed in mg/m^3 except carbon monoxide in mg/m^3
Annual average – Arithmetic mean of minimum of 104 measurements in a year taken twice a week 24 hourly at uniform interval
24 / 8 hourly values shall be met 98% of time in a year 2% of time, it may exceed but not on two consecutive days

Table 7.18
Annual Mean Concentration Range ($\mu G/M^3$)

Concentration	Industrial	SO_2	SPM	Residentia	SO_2 &NO›	SPM
Low	L	0-40	0-180	L	0-30	0-70
Moderate	M	40-80	180-360	M	30-60	70-140
High	H	80-120	360-540	H	60-90	140-210
Critical	C	>120	>540	C	>90	>210

B. Air Quality Data From NAAQM

Under the National Ambient Air Quality Monitoring Network, a number of stations have been established through out the country. In Bhubaneswar City the Ambient Air Quality is monitored at two locations viz; at Capital Police Station and at Over Head Tank, IRC Village, by the State Pollution Control Board, Orissa. The trend of the air quality in Bhubaneswar City is given in Table 7.19. Table – 7.20 shows the month wise air quality status in 2001 in Bhubaneswar City.

Table 7.19
National Ambient Air Quality Monitored (NAAQM)

Year	SPM (µg/m^3)		SO_2 (µg/m^3)		NOx (µg/m^3)	
	A	B	A	B	A	B
1998	91.6	102.9	7.9	8.9	39.9	33.8
1999	140	135	6.2	7.8	25.4	31.8
2000	152	152	7.3	6.8	24.5	23.2
2001	95	114	3.2	3.8	26.8	24.8
Standard (µg/m^3)	**140**	**140**	**60**	**60**	**60**	**60**

**** A – Capital Police Station, B – Over Head Tank, IRC Village***

Table 7.20
Monthly Ambient Air Quality Monitored at Capital Station & IRC VILLAGE, (2001)

Month	SO_2 (µg/m^3)		NOx (µg/m^3)		RPM (µg/m^3)		SPM (µg/m^3)	
	A	B	A	B	A	B	A	B
January	8.8	5.1	38.0	42.2	85.1	60.6	173.2	120.5
February	4.9	4.5	44.2	38.1	107.8	73.0	204.6	149.0
March	3.3	2.4	45.7	29.3	78.6	67.6	148.3	117.1
April	3.7	2.7	43.0	34.7	60.0	46.7	92.0	82.2
May	7.1	7.4	54.2	37.7	57.1	53.9	136.4	101.6
June	3.3	4.6	23.5	25.3	37.0	44.9	60.1	73.1
July	5.7	6.4	16.5	16.6	75.2	53.1	144.6	129.8
August	7.7	4.9	21.0	17.0	70.8	42.0	160.9	103
September	7.6	5.9	26.2	16.5	69.8	46.9	115.9	111.6
October	11.6	7.4	20.8	15.2	62.8	54.3	138.0	107.1
November	12.9	10.2	22.0	15.1	70.7	45.7	116.3	111.4
December	17.0	13.0	26.2	16.6	74.8	54.1	134.8	151.3
Annual Avg.	7.8	6.2	31.8	25.4	70.8	53.6	135.4	113.1
Standard	60	60	60	60	60	60	140	140

**** A – Capital Police Station, B – Over Head Tank, IRC Village***

Table 7.19 shows the ambient air quality data from NAAQM reports. Looking at the data for 1998, 1999 2000 and 2001, the ambient air quality is well within limits. The concentration of SPM and SOx is well within limits, however NOx although within limits but the concentration can be categorized as 'moderate'.

The monthly data shows the values for NOx although within limits, can be categorized as 'high' and 'moderate' for six months in the year 2001. Even SPM is exceeding the standards in two months of the year.

B. Air Quality Data Monitored for the EMP – Project

For the preparation of the Environmental Management Plan for Bhubaneswar City, several locations were chosen for the ambient air quality monitoring. The ambient air quality was monitored using IS 5182 methodology by considering typical parameters viz. SPM, NO_x and SO_2. Seventeen stations have been selected after review of the City in terms of industrial setup, traffic intersections, residential areas and the meteorological conditions. The data has been generated on eight-hourly basis for one day at every station in winter season i.e. in the month of December- January 2000-01. The monitored ambient air quality is presented in Table 7.21. Apart from these the major traffic corridor ambient air quality was also monitored on NH-5 during December 2002. In addition to the SPM, NO_x and SO_2, lead was also monitored.

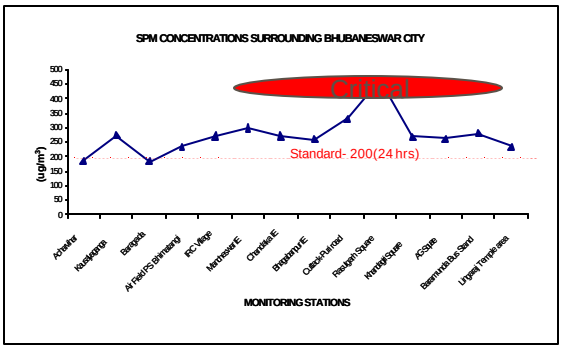
Table 7.21
Ambient Air Quality Results Of Bhubaneswar Area (December 2001)

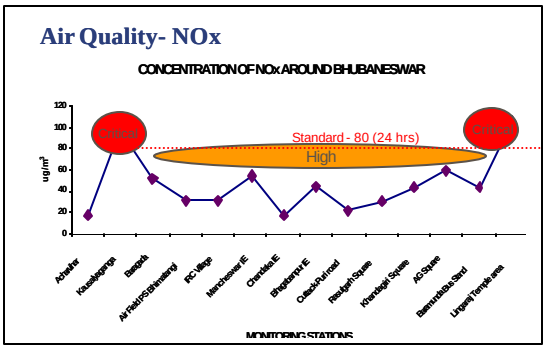
Sl	Monitoring Station	Ward No.	SO2 (µg/m³)	NOx (µg/m³)	RPM (µg/m³)	SPM (µg/m³)	SO2	NOx	SPM
1.	**RESIDENTAIL & Other Areas**								
2.	AcharyaVihar	08	5.1	17	106.89	187.92	L	L	H
3.	Kausalyaganga PS	11	2.6	96.95	90.5	317.87	L	C	C
			1.3	98.2	120.1	230.3	L	C	C
4.	Baragada Police Station	24	6.2	82.0	110.9	244.4	L	C	C
			8.6	21.0	60.35	122.15	L	L	H
5.	Air Field Police Station, Bhimatangi	29	4.9	19.17	162.65	391.56	L	L	C
			3.7	17.2	113.02	175.80	L	L	H
			6.8	43.15	124.5	192.9	L	M	H
			9.21	46.08	110.30	189.35	L	M	C
6.	IRC Village	14	7.70	27.40	145.79	283.69	L	M	C
			6.5	33.53	132.15	262.18	L	M	C
7.	Cuttack-Puri Road	23	9.4	13.27	98.61	386.57	L	L	C
			6.2	30.84	123.50	278.87	L	M	C
8.	Rasulgarh Police Station	03	17.43	41.67	251.48	877.22	L	M	C
			7.55	36.64	115.20	223.35	L	M	C
			3.3	10.83	170.94	295.82	L	L	C
9.	Khandagiri Police Station	17	2.61	42.82	79.54	268.17	L	M	C
10.	Traffic Inspector Office, AG Chhak	21	4.3	90.0	152.1	371.1	L	C	C
			3.6	44.35	67.75	123.15	L	M	H
			4.9	42.6	163.9	295.6	L	M	C
11.	Baramunda Bus Stand	16	3.8	70.71	191.16	380.51	L	H	H
			8.35	15.36	105.11	178.15	L	L	L
	INDUSTRIAL AREAS								
12.	Mancheswar IE	02	8.6	41.46	201.77	372.50	L	M	H
			6.5	66.68	102.25	225.65	L	H	M
13.	Chandaka IE	01	4.1	17.0	106.89	187.92	L	L	H
			5.2	18.64	112.18	225.30	L	L	M
			8.82	14.48	163.81	405.81	L	L	H
14.	Bhagawanpur IE	19	6.6	10.78	85.7	261.06	L	L	H
15.	Tamando		12.0	26.0	75.5	597.04	L	L	C
	SENSITIVE AREA								
16.	Khandagiri Police Station	17	2.61	42.82	79.54	268.17	L	M	C
17.	Lingaraj Temple area	26	4.0	72.14	103.7	379.7	L	H	C
			2.9	77.86	95.83	187.18	L	H	C
			13.7	66.8	164.9	236.0	L	H	C
			8.5	64.05	75.15	138.90	L	H	H

Source: State Pollution Control Board, Bhubaneswar, Orissa ***Note*** 1. All values are in µg/m³ 2. The values are based on monitored data for ≥16 hrs/day

Table 7.22
Ambient Air Quality Monitored Along NH-5- in December 2002

Sl.	Name of the Place	Parameter			
		SPM ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	NOx ($\mu g/m^3$)	Pb ($\mu g/m^3$)
1	Tamando	597.0	12.0	26.0	0.007
2	Baramunda	1180.0	28.0	72.0	0.06
3	Jayadev Vihar	510.6	14.4	42.0	0.011
4	Vani Vihar	841.5	16.4	62.0	0.016
5	Rasulgarh	431.6	12.0	28.0	0.032





Based on the monitored data for the project it is found that the SO2 in most of the areas is 'low' NOx at most of the locations are on higher side and can be categorized as 'moderate' to 'high'. Traffic and transport could be reason. SPM is 'high' to 'critical' at most of the locations. This may be due to the natural dust and the location of the stone crushers in the city area. Bhubaneswar city is well within limit.

Public Complaints

A number of cases related to the impact of stone crushers to the environment have been registered in the court.

Conclusion

Based on above data, field observations and increasing public complaints, although, the concentration of SO_2 is well within limits at some location but there is extremely high concentration of SPM at some locations. The concentration of NOx at many locations is high as per the monitoring conducted by SPC Board, Orissa during the EMP study. However, the NAAQM data shows the air quality to be within limits.
Based on Air Pollution, the city is categorized into Highly Critical Areas, Moderately Critical Areas, and Critical Areas as below and shown in Map:

Impact areas	Areas
Highly Critical Areas	Bhagabanpur, Patrapada, Aignia, Unit – 20, Shankarpur, Khandagiri, Udaygiri, Dumuduma and areas all along National Highway 5 and 203
Moderately Critical Areas	Core area of the city
Critical Areas	Jaganath prasad, Sundarpur, Chandrasekharpur, Bharatpur, Sampur, Malipada, Andharua areas of the city.

From the above data, it can be observed that the concentration of SPM is high at all the locations and may be categorised as 'critical'. The concentrations of SO2 and NOx are within limits.