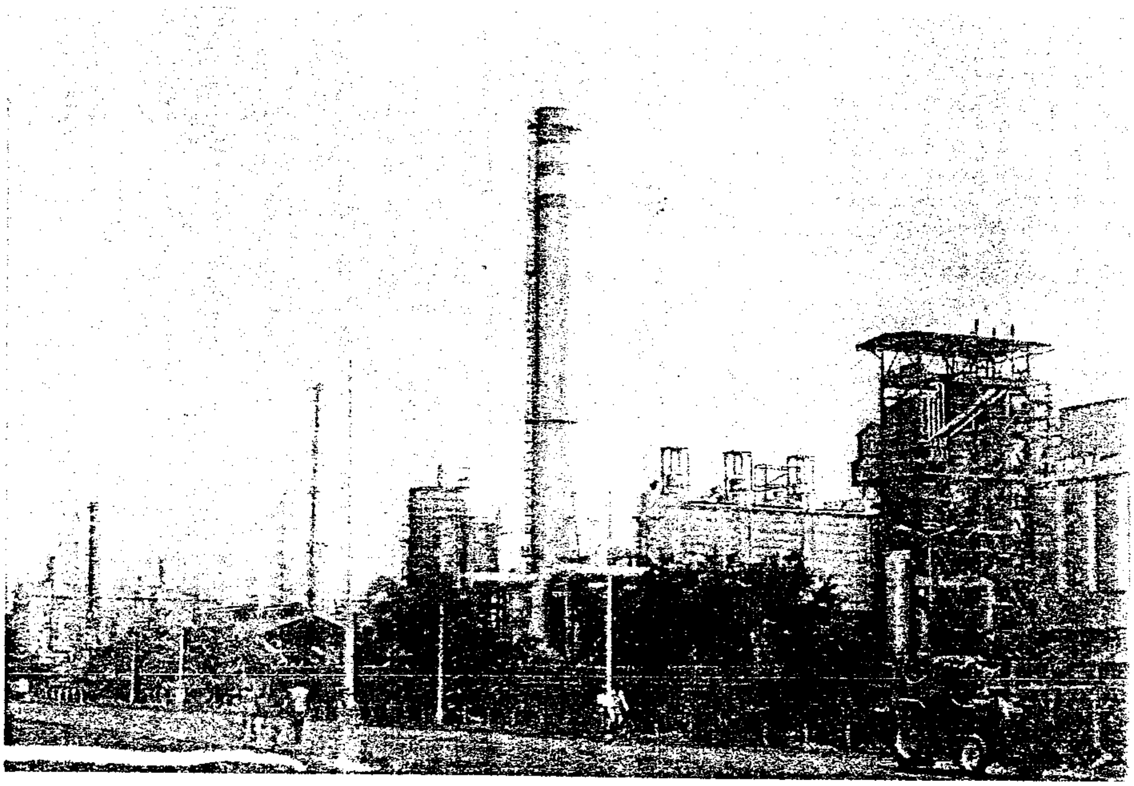
Revised Draft Final Report

Assessment of Contribution of Industrial Sources to the Ambient Air Quality of Raipur Region



Sponsor:

Chhattisgarh Environment Conservation Board (CECB), Raipur

National Environmental Engineering Research Institute
(NEERI), Nehru Marg, Nagpur - 440 020 (India)

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Chapter 1

Introduction

Chapter 1

Introduction

1.1 Salient Features of Chhattisgarh State/Raipur Region

1.1.1 General

After getting the status of a separate State in 2000, Chhattisgarh State has attracted a large number of metallurgical and power industries in the State. Other economic activities have also grown at a faster pace in the State. Raipur, being the capital city, has witnessed exponential development and economic growth. Number of vehicles on roads have also increased manifold. It has been recognized that Raipur is facing tremendous environmental pollution problem, mainly air pollution caused by number of air polluting industries viz. Sponge iron, ferro alloy, power plants and rolling mills existing in the region. The problem is further aggravated due to increased vehicular movement, bad condition of roads, poorly maintained vehicles, and construction activities.

Chhattisgarh Environment Conservation Board (CECB), Raipur is keen to know the contribution of industrial sources to the total air pollution in and around Raipur city to decide on future strategies to deal with the matter of pollution effectively. Therefore, CECB retained National Environmental Engineering Research Institute (NEERI), Nagpur, to carry out a study on assessing the contribution of air polluting industrial sources in the Raipur region, which includes Raipur city and it's surrounding industrial areas, so that appropriate remedial measures for improvement in air quality of the region can be taken.

Prior to discussing the study specific components, first background information with respect to mineral and coal resource base, land use pattern, demographic details and industrial activities of Chhattisgarh and Raipur district are presented.

"The Madhya Pradesh Reorganization Act-2000" paved the way for the creation of Chhattisgarh on 25th August 2000. The State of Madhya Pradesh was bifurcated into Chhattisgarh and Madhya Pradesh on the First day of November 2000 by the Government of India. The State of Chhattisgarh lies between 17°46" to 24° 06" N latitude and 80°15" to 84°51" E longitude. The State measures 640 km from North to South and 336 km from East to West with a total area of 1,37,898 sq.km. Jagdalpur is the largest district (17,016 Sq Km) while Kawardha is the smallest district (3,958 Sq Km) in area. Administrative map of Chhattisgarh State and Raipur Region is shown in **Fig. 1.1.1**.

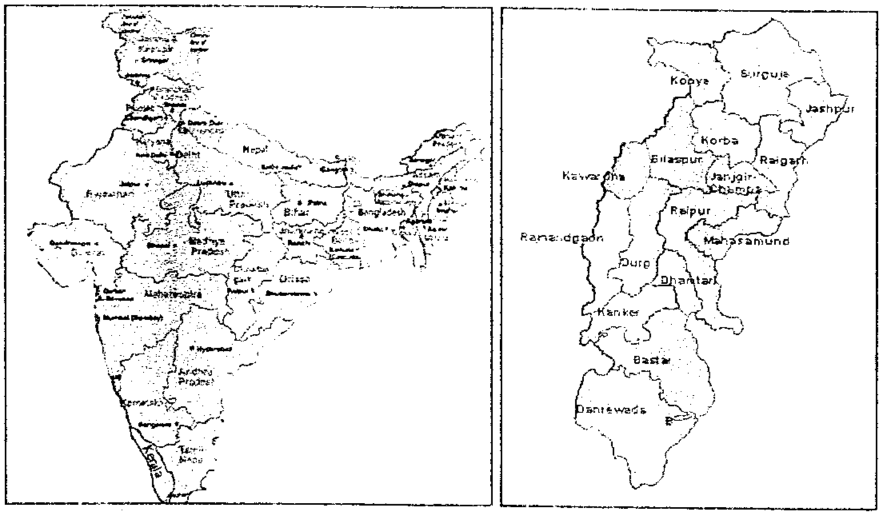


Fig. 1.1.1: Location of Chhattisgarh and Raipur District in the Country/State Map

The state has 5 river basins, namely Mahanadi, Godavari, Narmada, Ganga and Brahmani, with a total drainage area of 137,360 sq. Km. River waters are mainly utilized for irrigation, urban water supply and aquaculture. The estimated surface water available for use is around 41,720 million cubic meters (MCM). Main rivers of the state are Mahanadi, Indravati, Hasdeo, Seonath, Arpa and Eib. Annual rainfall in the state is around 1200-1500 mm.

Raipur, the capital city of Chhattisgarh state, is located on two National Highways (NH), NH 6 (Surat-Kolkata) and NH 43 (Raipur-Chittivalasa, near Visakhapatnam in Andhra Pradesh). The Mumbai-Howrah railway line, one of the busiest railway lines in term of goods and passengers, passes through the city. The Raipur district covers an area of 13,083 sq. km and lies between North latitudes 19°46' and 21°50' and East longitudes 81°25' to 83°16' with population of 30.1 lakhs (as per 2001 census). The city is a fast developing industrial, commercial and administrative centre. It is one of the largest growing urban settlements in Chhattisgarh. The population of Raipur city was about 6.7 lakh in 2001, and according to the 2001 census, it is the 55th largest city agglomeration in India. It is projected to increase to about 13 lakhs by 2011 with a decadal growth rate of 95% (Source: http://niua.org/jnnurm/CDPAppraisal_Raipur_NIUA.pdf). The city is located centrally in the state of Chhattisgarh, and now serves as a regional hub for trade and commerce for a variety of local agricultural and forest products.

The land use pattern of the district indicates that 42% of the area is occupied by the agricultural land. The district receives a normal rainfall of 1385 mm with 65 rainy days. The district has a tropical climatic condition and the entire district falls under Mahanadi Basin- main tributaries being Seonath, Jok and Tel. The chemical quality of the ground water in both shallow aquifers as well as deeper aquifers is reported to be good and suitable for drinking, irrigation and industrial purposes.

1.1.2 Mineral Resources in the State

Chhattisgarh hosts a wide variety of minerals found in igneous, sedimentary and metamorphic terrains. Large deposits of Coal, Iron ore, Limestone, Bauxite, Dolomite and Tin ore are located in several parts of the state. Lately, Diamondiferous Kimberlites identified in Raipur district are likely to yield substantial quantity of Diamonds. Medium to small deposits of gold, base metals, quartzite, soap stone, Statite, Fluroite, Corrundum, Graphite, Lepidolite, Amblygonite of workable size are also likely to graduate to the category of large deposits after prospecting. Twenty percent of the country's steel and cement is produced in the State. It is the only tin-ore producing state in the country. The mineral resources have immense potential for large investment in mining, setting of mineral based industries and generating employment. Chhattisgarh is nestling atop the world's largest Kimberlite area. Eight blocks have been demarcated for diamond exploration. Apart from diamond, four blocks of gold exploration and five blocks for base metal investigation have been demarcated (Source: http://forest.cg.gov.in/AboutCG.htm).

Chhattisgarh is the richest State in terms of mineral wealth. With over 28 kinds of major and minor minerals present in the State, Chhattisgarh is the leader in terms of mineral potential among all the States. Deposits of few major minerals in the State are as: Coal- 41,442 million tons, Iron ore: 2,731 million tons, Lime stone: 9,038 million tons, Dolomite: 847 million tons, Bauxite: 148 million tons and Cassiterite: 29 million tons (Source: http://chhattisgarh.nic.in/mining/mining.pdf). Region and grade-wise reserves of some mineral resources of the State is given in Table 1.1.1.

Table 1.1.1: Mineral Resource Base of Chhattisgarh State

Mineral	Region	Grade	Reserve
Limestone	Mandhar, Matiya, Dondekalan etc., Bahesar, Mansa, Puani, Siliyari, Siliyari, Tarra, Pathari, Khudmudi, Jhipan, Rawan, Pendri, Ameri, Hirmi, Saklor, Parswani, Karhichandi, Semradih, Mohra, Phrhada, Khelwari, Rawan, Pausari, Kukurdi, Sonadih, Rasera, Raseri, Gaitara, Maldimopar, Shuklabhata, Chichpol, Amilidih	Cement grade	1,493 million metric tons
Gold	Sonakhan, Bagmara	3 g/T	2,780 kg
Diamond	Beheradih, Payalikhand	Gem / off colour industrial	NA
Alexandrite	Sandmura	Gem	NA
Garnet	Gohekala, Dhupkot, Thirliguda	Semi- precious	16 tonnes
Dolomite	Dhaneli, Tikulia, Gandadih	BF /SMS	19 million metric tons
Flag Stone	Banks of Mahanadi	Low grade	Small deposits

Source: http://www.raipur.gov.in (as seen on Oct 24, 2009)

1.1.3 Coal Reserves

As a result of exploration carried out up to the depth of 1200 m by the GSI, CMPDI and MECL etc., a cumulative total of 2,67,210 million metric tonnes (MMT) of Geological Resources of Coal have so far been estimated in the country (as on 1.4.2009). Of the total coal reserves of the country, share of Chhattisgarh is 16.6% (44,483 MMT), whereas of the total proven coal reserves (105,820 MMT), share of Chhattisgarh is about 10.3% (10,910 MMT). Estimated coal reserves in Chhattisgarh and India are presented in **Fig. 1.1.2**.

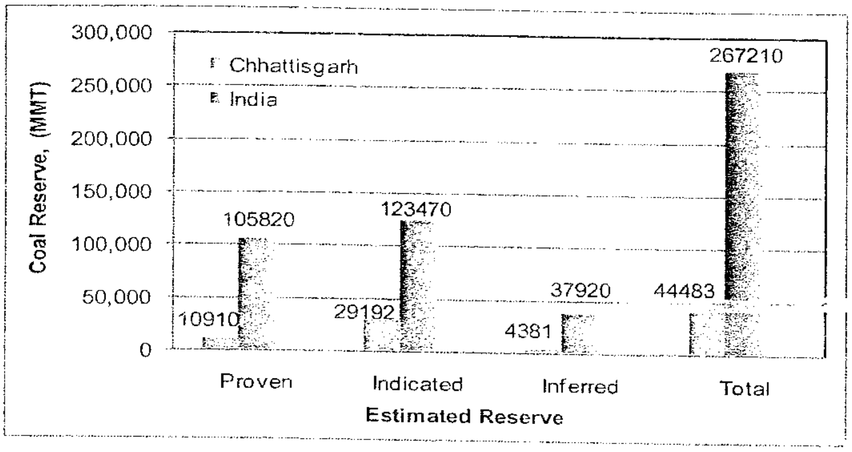


Fig. 1.1.2: Geological Resources of Coal (MMT) in Chhattisgarh and India

Different grades (semi-coking coal grade I &II, Grade A to F) of coal are produced in Chhattisgarh State. The grading depends on the ash content of the coal, Grade A contains less ash content and it increases to Grade F coal. Grade-wise production of coal during 2000-01 to 2005-06 is given **in Table 1.1.2**.

Table 1.1.2: Year and Grade-wise Production of Coal in Chhattisgarh: 2000-01 to 2005-2006

Financial Year	Grade wise Production of Coal, (million metric tonnes)						
	Semi-coking coal grade- I,II	A	B	C	D	F	Total
2000-01	0.149	0.783	5.715	3.967	0.517	39.095	50.226
2001-02	0.146	0.781	5.869	3.734	0.535	42.612	53.677
2002-03	0.146	0.789	6.226	3.814	0.758	45.025	56.758
2003-04	0.148	0.835	6.617	3.922	0.839	49.144	61.505
2004-05	0.146	0.897	7.164	3.775	1.072	56.196	69.250
2005-06	0.150	1.063	7.669	4.125	1.213	62.138	76.358

The total production of coal in 2000-01 was 50.226 MMT, which increased to 76.358 MMT in 2005-06, registering a growth of about 52% in 6 years. Among the different grades of coals, production of Grade F coal was maximum, followed by Grade B, C, D, A and Semi-coking coal. Production pattern of different Grades of coal for 2005-06 is shown in **Fig. 1.1.3**.

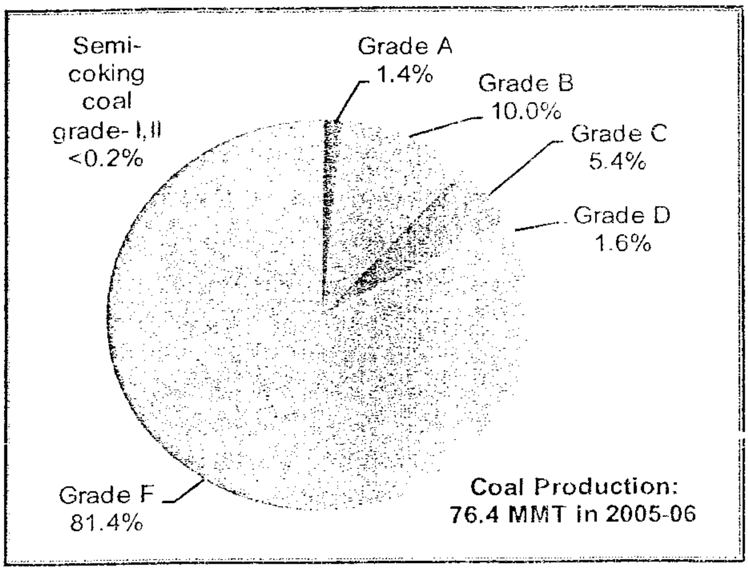


Fig. 1.1.3: Grade-wise Percentage Coal Production in Chhattisgarh during 2005-06

District and Grade-wise production of coal in Chhattisgarh during 2004-05 and 2005-06 is given in **Table 1.1.3**. Korba region tops in coal production. Koriya, Raigarh and Surguja follow. Korba and Raigarh region produce mainly F-grade coal, whereas Koriya region produces all grades (except F) and Surguja produces mainly C & D grade coal. Of the total coal production, as much as 79% coal was of Grade F in 2004-05 and 81.4% in 2005-06.

Table 1.1.3: District and Grade-wise Production of Coal in Chhattisgarh during 2004-2005 and 2005-2006

Grade of Coal	Coal Production, (million metric tons)				
	Korba	Koriya	Surguja	Raigarh	Total
2004-05					
Semi-coking coal grade-I, II	0	0.146	0	0	0.146
Grade-A	0	0.897	0	0	0.897
Grade-B	1.397	2.942	2.825	0	7.164
Grade-C	0.619	2.021	1.135	0	3.775
Grade-D	0	0.588	0	0.484	1.072
Grade-F	52.744	0	0	3.452	56.196
Total	54.760	6.594	3.960	3.936	69.250

2005-06					
Semi-coking coal grade-I, II	0	0.150	0	0	0.150
Grade-A	0	1.063	0	0	1.063
Grade-B	1.495	3.198	2.976	0	7.669
Grade-C	0.696	2.225	1.204	0	4.125
Grade-D	0	0.3.97	0	0.816	1.213
Grade-F	56.048	0	0	6.092	62.138
Total	**58.237**	**7.033**	**4.180**	**6.908**	**76.358**

Source: Mineral Resources Department, Govt. of Chhattisgarh

1.1.4 Demographic Status

As per 2001 Census, the total population of the State was around 20 million, which was 2.035% of the nation's population. Of the total population, about 80% are rural and rest 20% are urban masses. Literacy rate in Chhattisgarh is 53.6%, whereas in Raipur district it is slightly higher (56.8%). Male literacy in the State is 64.1%, whereas in district it is 67.9%. Female literacy is 43.1% in the State and 45.5% in the district. Overall sex ratio (number of females per 1000 male population) is 989 in the State and 980 in the Raipur district. Children below 6 years of age are about 17%. Demographic details of Chhattisgarh and Raipur district are given in **Table 1.1.4**.

Table 1.1.4: Demographic Details of Chhattisgarh State and Raipur District (Census of India, 2001)

Particulars	Total	Rural	Urban	Literates	Children in the age group (0-6 years)
Chhattisgarh State					
Total Population	2,08,33,803	1,66,48,056	41,85,747	1,11,73,149	35,54,916
Males	1,04,74,218	83,07,443	21,66,775	67,11,395	18,00,413
Females	1,03,59,585	83,40,613	20,18,972	44,61,754	17,54,503
Sex Ratio	989	1004	932	665	975
Raipur District					
Total Population	30,16,980	20,99,312	9,17,618	17,13,653	5,15,582
Males	15,23,925	10,47,633	4,76,292	10,34,063	2,62,406
Females	14,93,005	10,51,679	4,41,326	6,79,590	2,53,176
Sex Ratio	980	1004	927	657	965

As per 2001 Census, the density of population in the State is 154 persons/sq km, whereas for the District, it is 231 persons/sq km. The population density in urban areas of the State is 2,243 persons/ sq km, whereas in Raipur district, it is 3,771 persons/sq km. In the rural areas, population density in the State and Raipur district is 125 persons/sq km and 164 persons/sq km, respectively (Fig. 1.1.4)

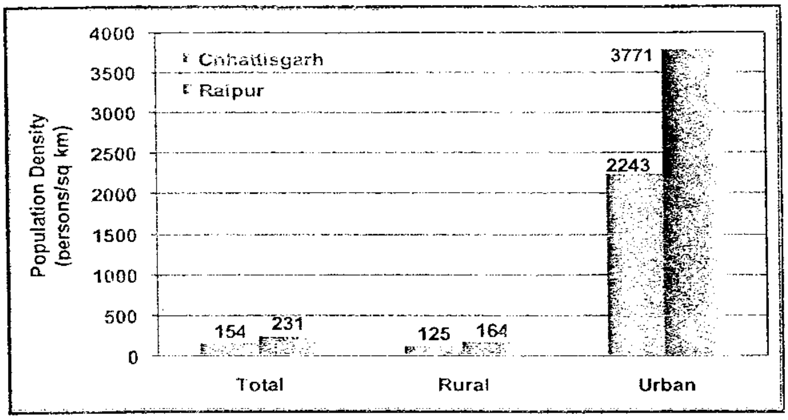


Fig. 1.1.4: Population Density in Chhattisgarh and Raipur District (as per Census 2001)

1.1.5 Land use Pattern/Forest Cover

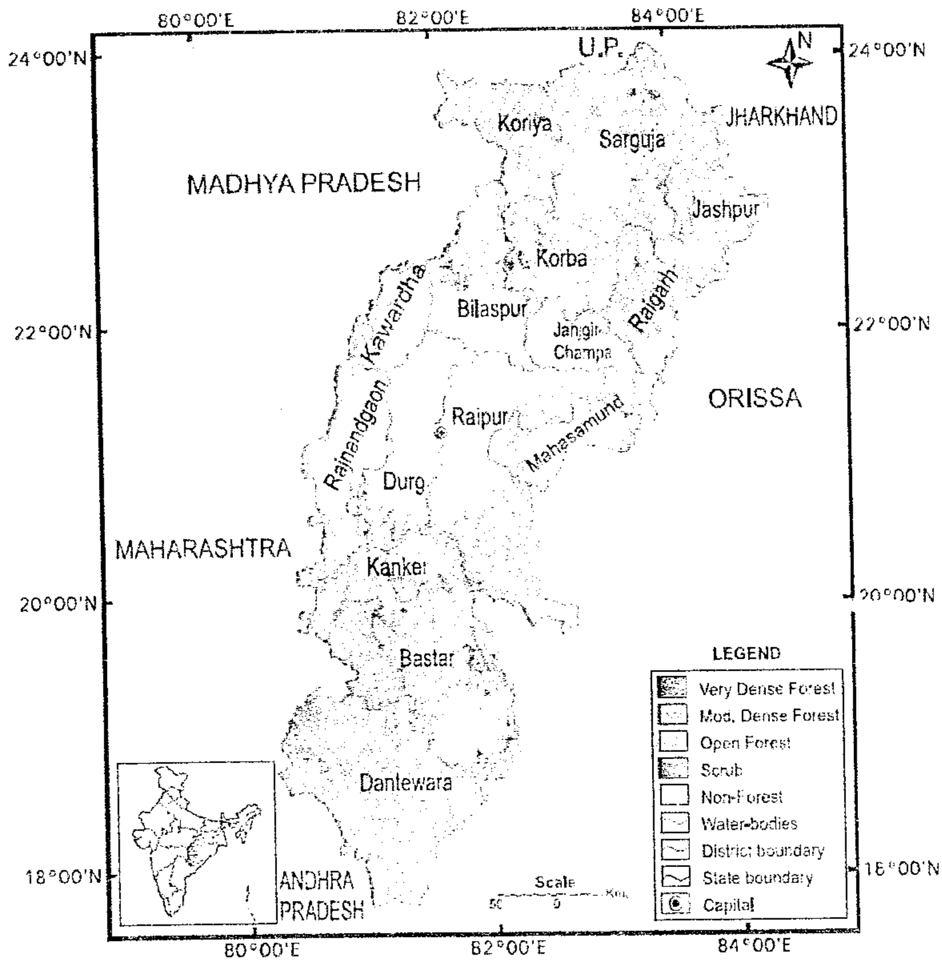
The Chhattisgarh State covers 4.4% of the total geographical area of the country. The State has about 12% of the India's forests, and 46% of the State's land is under forests. Land use pattern of Chhattisgarh State is given in **Table 1.1.5**.

Table 1.1.5: Land use Pattern of Chhattisgarh State

Sr. No.	Land Use	Area (sq km)	Area (%)
1.	Total Geographical Area	137,898	
2.	Forest Area (including Revenue Forests)	63,543	46.08
3.	Land not Available for Agriculture	9,956	7.22
4.	Culturable fallow land & unculturable land	12,080	8.76
5.	Fallow lands – Current & Old	5,102	3.70
6.	Net area sown	47,216	34.24

(Source: Chhattisgarh at a Glance 2007, Directorate of Economics and Statistics, Chhattisgarh, website: http://www.descg.gov.in/publications.aspx)

Apart from rich forest cover, net area sown is 34.24% and the area not available/suitable for cultivation is 7.22%. Fallow land is 3.70% of the total State's land. Forest cover map of Chhattisgarh is shown in **Fig. 1.1.5**.

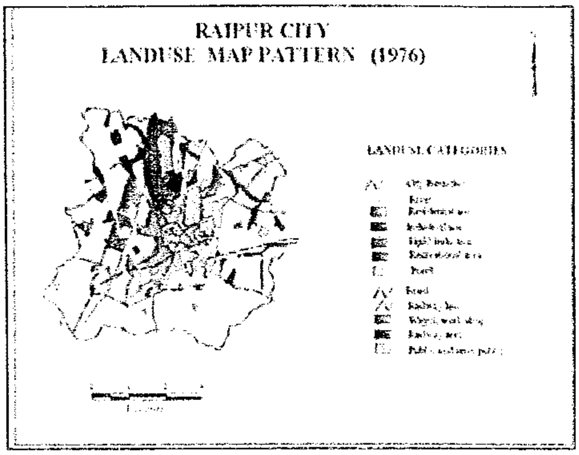


(Source: State of Forest Report 2005, Chhattisgarh)

Fig. 1.1.5: Forest Cover Map of Chhattisgarh

Identified as one of the richest bio-diversity habitats, the Green State of Chhattisgarh has the densest forests in India, and above all, over 200 non-timber forest products, with tremendous potential for value addition exists in the State. Its forest eco-system is very rich in Non-Wood Forest Products. The trade of Non-Wood Forest Products is more than one lakh tons in terms of quantity and Rs. 575 Crores in terms of value.

Forest cover is more in northern and southern part, with very less forest cover in the central part of the State that is the region surrounding Raipur district. Raipur serves as an administrative centre for Chhattisgarh State. The city is required to hold administrative entities of all the hierarchies, viz. State division or zone, district and local level. Land use pattern of Raipur city in 1976 and 2001 is depicted in **Fig. 1.1.6**.



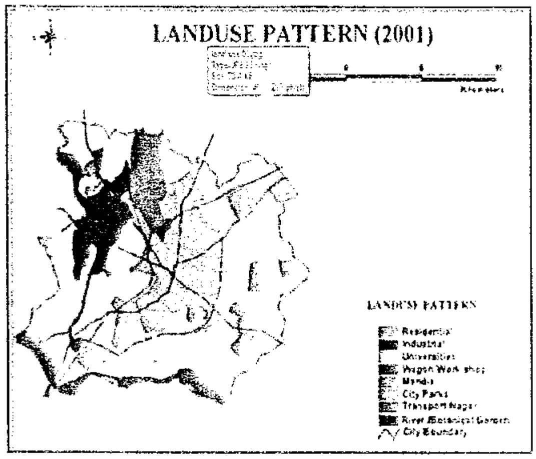


Fig. 1.1.6: Land use Map of Raiput City in 1976 and 2001

It is evident from these figures that over the last 25 years, the usage of land in Raipur district has increased drastically for Industrial purposes. Land use for residential purpose has also increased during this period.

1.1.6 Agriculture

Chhattisgarh has good agricultural base also, and it accounts for more than 70% of the total paddy production in the country. Apart from paddy, cereals like maize, kodo-kutki and other small millets, pulses like tur and kulthi and oilseeds like groundnut, soyabean, niger and sunflower are also grown. Major livestock in the State are cattle, bovines, sheep, and goats.

Area under agriculture and production of principle crops (as cereals, pulses, oilseeds sugar cane and others) along with their yields in Chhattisgarh during the years 2004-05 to 2007-08 are presented in **Table 1.1.6.** Total cereals include Wheat, Maize, Paddy (Summer) & Jowar. Total pulses Include Gram, Pea, Lintel, Moong, Urad, Kulthi, Teora (Lakhodi) & Others and total oilseeds includes Rapeseed & Mustard, Linseed crop, Safflower, Sunflower, Til, Groundnut and Ramtil.

Table 1.1.6: Yearly Production and Yield of Principle Crops in Chhattisgarh: 2004-2008

Particulars	Total Cereals	Total Pulses	Total Oilseed	Sugar-cane	Other Crops
2004 – 2005					
Area, (1000 ha)	243	911	351	16.72	122
Production, (1000 MT)	326	383	116	42	0
Yield, (kg/ha)	1343	420	330	2511	0
2005 – 2006					
Area, (1000 ha)	272	968	342	20.37	134
Production, (1000 MT)	325	502	110	51.55	0
Yield, (kg/ha)	1192	518	323	2530	0

2006 – 2007 (Final Forecast)					
Area, (1000 ha)	334	864	294	21.9	134
Production*, (1000 MT)	594	508	106	56.0	0
Yield*, (kg/ha)	1778	588	359	2559	0
2007 – 2008 (Final Forecast)					
Area, (1000 ha)	347	936	325	23.6	152
Production*, (1000 MT)	592	589	125	65.4	0
Yield*, (kg/ha)	1705	629	386	2768	0

(Source: www.indiastat.com, as seen on April 1, 2010)

1.1.7 Industrial Activities

Chhattisgarh has one of the foremost industrial areas of the Country in Bhilai that houses numerous ancillary industries around the Country's most profitable steel plant in the Public Sector. There is a similar concentration of industries in Korba, with power plants of the National Thermal Power Corporation, the Chhattisgarh State Electricity Board and aluminium producing unit BALCO. Strategically located in central India, Chhattisgarh's large surplus of power can be easily transmitted without losses to any of India's four grids.

Chhattisgarh State Industrial Development Corporation (CSIDC) has developed many industrial growth centres in the State like; Urla and Siltara (both in Raipur), Borai in Durg, Sirgitti in Bilaspur and Anjani in Pendra Road. Various developmental activities proposed for the State are depicted in **Fig. 1.1.7.**

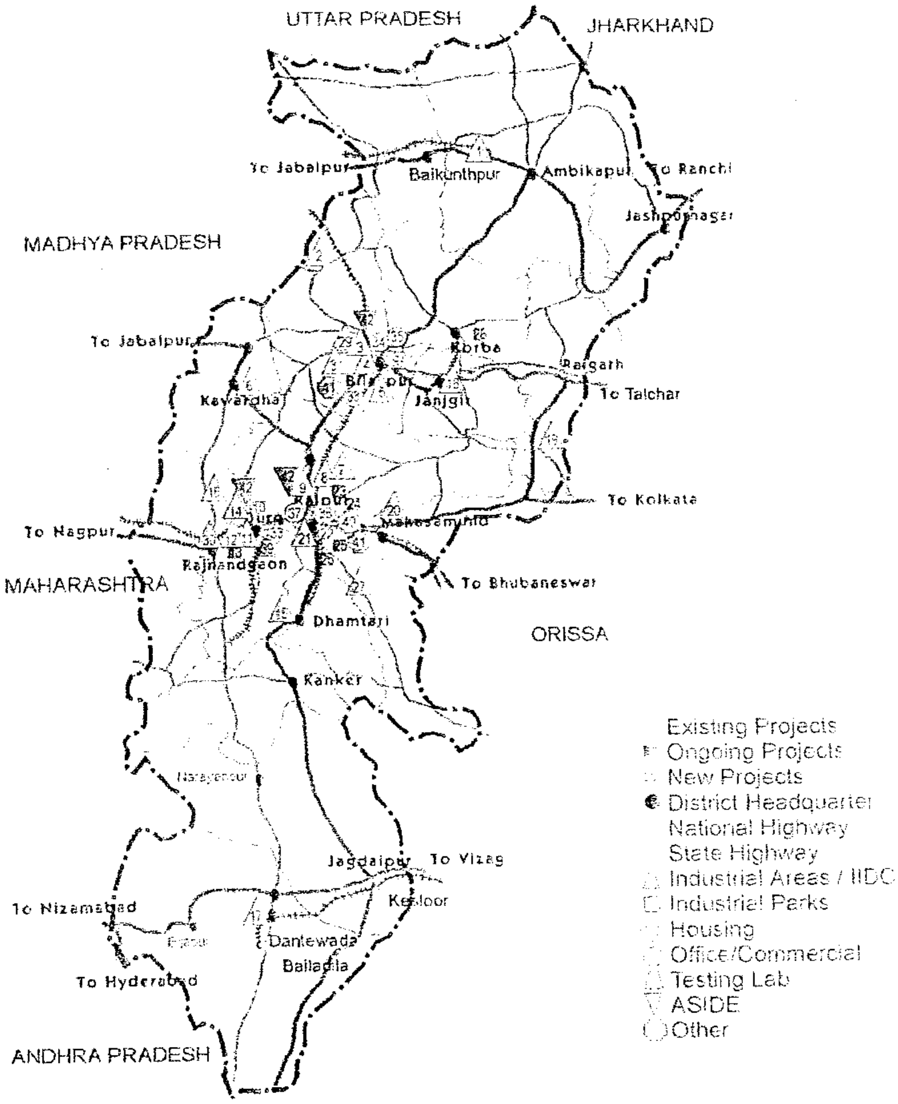


Fig. 1.1.7: Map showing Various Developmental Activities in Chhattisgarh State (Source: CSIDC)

Siltara and Urla are the two major industrial areas under Raipur region, which are of interest from the current study point of view. The details and salient features of these industrial areas are presented in the subsequent chapter.

1.1.8 Vehicular Status

According to the Directorate of Economics and Statistics, the total number of vehicles in the Chhattisgarh increased from 7,12,976 in 1999-2000 to 7,81,469 in 2000-2001 (9.61% rise) and to 8,56,840 in 2001-2002 (10.91% rise). As on April 1, 2004, the total number of registered vehicles (under different categories) in Chhattisgarh State and Raipur are given in Table 1.1.7.

Table 1.1.7: Number of Registered Vehicles in Chhattisgarh and Raipur (as on April 1, 2004)

Sr. No.	Category	Chhattisgarh	Raipur
1.	Tempo	2204	493
2.	Auto-rickshaw	5270	2315
3.	Scooters & motor cycles	724073	165728
4.	Moped	266949	59323
5.	Car	43572	16937
6.	Jeeps	7302	606
7.	Tractors	44321	13132
8.	Trailors	38804	12471
9.	Others	2103	639
	Total	**12,15,745**	**3,06,347**

(Source: www.indiastat.com)

Out of the total vehicles, as much as 81.5% vehicles were 2 wheelers (scooters, motor cycles & mopeds) in the State, while in Raipur district 2 wheelers were about 73.5%.

By March 2007, total number of registered vehicles increased to 17.28 lakhs in the State (increased by 42% as compared to 2004). Breakup of different category vehicles is shown in **Fig. 1.1.8**.

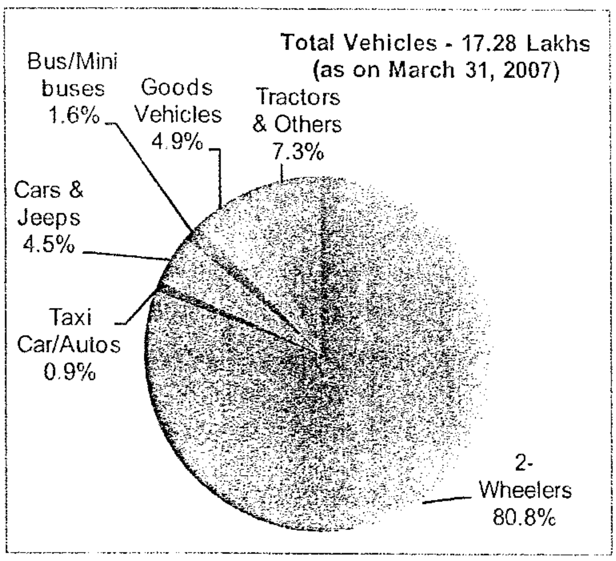


Fig. 1.1.8: Break up of Total Registered Vehicles in Chhattisgarh State (as on March 31, 2007)

As on October 1, 2009, the total number of registered vehicles in Raipur was 406,559, which increased by about 33% in 5 & 1/2 years. In 2004, the number of vehicles per 1000 population of Chhattisgarh and Raipur district were about 58 and 102, respectively.

As on April 1, 2007, total length of the roads in the State was 36066 km, of which 2228 km are as National Highways, 3213 km as State Highways, 4814 km as major district roads and 25811 rural roads. Of the total roads, 27974 km are surfaced roads (16830 km black topped, 11036 km water macadam and 108 km concrete roads), and total unsurfaced roads are 8092 km. Besides, 9222 km roads are laid down under Pradhan Mantri Gram Sadak Yojna.

Chhattisgarh currently has about 25 km of road length for every 100 km^2 of area. The length of tarred road in Raipur amounts to 11,195 km and that of non-tarred road to 4,019 km. Most of the roads are unpaved/un-tarred, and they cause more emissions of pollutants due to fuel wastage from vehicles as well as dust pollution from unpaved roads.

1.2 Air Quality Status of Raipur Region

Ambient air quality status is being assessed through monitoring of major criteria pollutants, viz. suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2). These parameters are being monitored under National Air Monitoring Programme (NAMP) by the Chhattisgarh Environment Conservation Board (CECB) at three locations in Raipur city for a long time. The three sampling stations are located at New H.I.G. 9, Hirapur (represents residential activities), Jai Stambh Chowk (represents commercial/traffic activities) and M/s Wool Worth (I) Ltd., Sarora (represents industrial activities).

Sampling and analysis of these parameters is done as per the CPCB protocol. Sampling for SPM and RSPM is done on 8 hrly basis, whereas sampling for SO_2 and NO_2 is done on 4 hrly basis for a day. 24 hourly average values are obtained by averaging the 3 observations each for SPM & RSPM and 6 observations each for SO_2 & NO_2. Monitoring frequency is twice a week, thus in year, sampling is done for 104 days. The annual average value is calculated as the average of 104 days values.

Air quality data available with CECB at the 3 locations of Raipur region for the years 2001-2008 has been analyzed for RSPM, SPM, SO_2 and NO_2. Monitored annual average values are compared with the revised air quality standards (MoEF Notification, dated Nov 18, 2009) for RSPM, SO_2 and NO_2. SPM has been compared with earlier air quality standards as this parameter has not been included in the revised standards.

The revised air quality standards (select parameters relevant for the study) for industrial, residential, rural and other areas (other than ecologically sensitive areas) are given in **Table 1.2.1**. Complete list of parameters included in the revised air quality standards is given in **Annexure A (Table A.1.1)**.

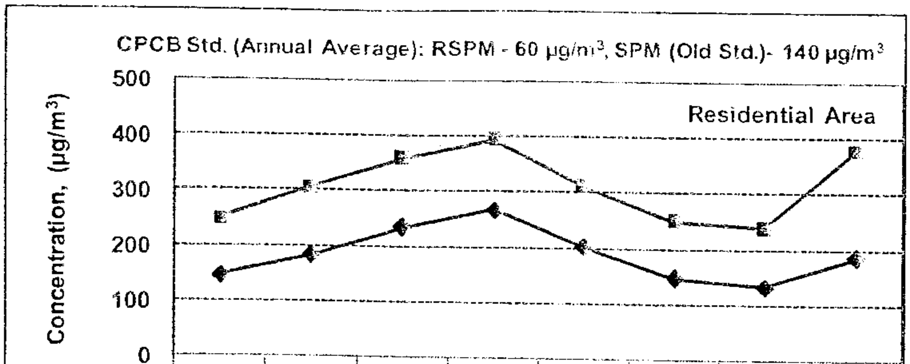
Table 1.2.1: Revised National Air Quality Standards (Select Parameters)

Parameter	Time Weighted Average	Industrial, Residential, Rural and other areas (µg/m^3)	Ecologically Sensitive areas (µg/m^3)
PM_{10}/RSPM (Particulate matter <10 µ size)	24 Hourly	100	100
	Annual	60	60
SO_2	24 Hourly	80	80
	Annual	50	20
NO_2	24 Hourly	80	80
	Annual	40	30
CO (mg/m^3)	1 Hourly	4	4
	8 Hourly	2	2

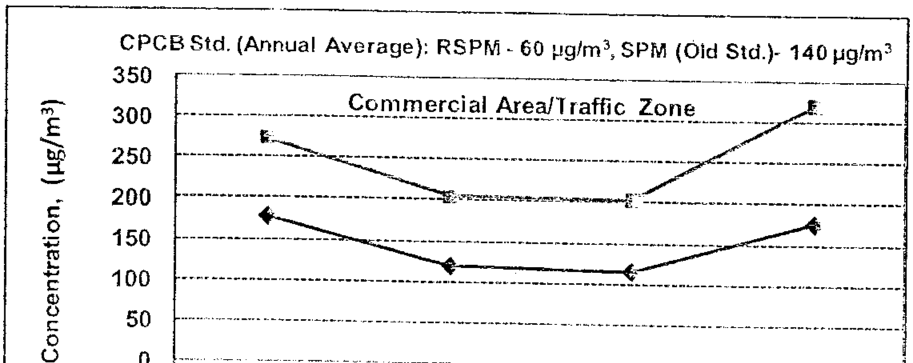
Ambient air quality data generated by CECB at 3 locations under the NAMP (National Air Monitoring Programme) is presented through **Fig. 1.2.1** and **Fig. 1.2.2** respectively for RSPM & SPM and SO_2 & NO_2 during the period 2001-2008. The values are also indicated in the figures. Perusal of **Fig. 1.2.1** indicates increasing trend in RSPM and SPM levels at residential and industrial area sites during 2001 to 2004 and then a decreasing trend up to 2007. Further, increase in levels is observed in 2008. Similar trend is observed at commercial area/traffic activity zone monitoring site.

Overall, RSPM & SPM levels were found to be considerably high as compared to the prescribed CPCB Standard at all the sites. SPM is not included in the revised standards, however for comparison purpose pre-revised values of the standard have been considered.

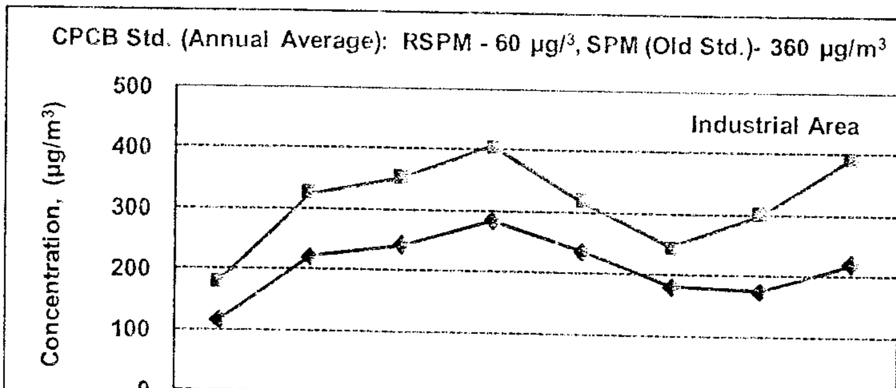
Perusal of **Fig. 1.2.2** indicates gradual increase in SO_2 levels up to 2007, and then significant increase in 2008 at all the three monitoring locations. Almost similar trend is observed for NO_2 concentration levels. The concentration levels of SO_2 (18-20 µg/m^3 in 2008) are within the permissible limit of 50 µg/m^3, however increasing trends are observed at all the three monitoring locations. The concentration levels of NO_2 are close to the permissible limit of 40 µg/m^3, however the levels have exceeded (42-45 µg/m^3 marginally at all the three monitoring locations in 2008. Thus, there is a need for immediate action for control of these air pollutants, namely RSPM and NO_2.



	2001	2002	2003	2004	2005	2006	2007	2008
RSPM	146	183	234	269	203	148	133	186
SPM	249	306	359	394	311	251	239	380

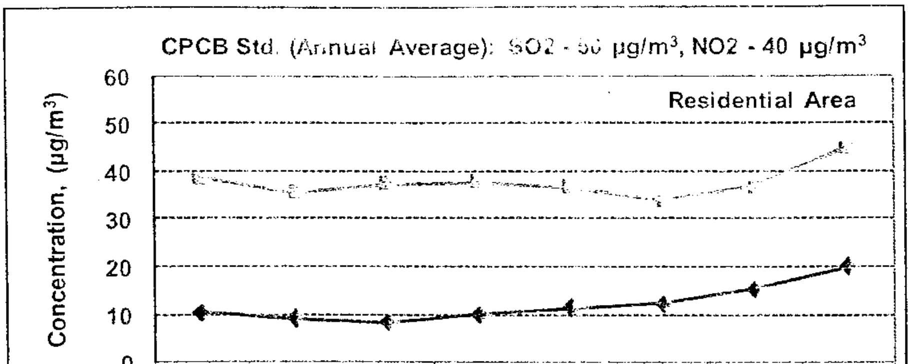


	2005	2006	2007	2008
RSPM	176	118	114	174
SPM	273	204	202	320

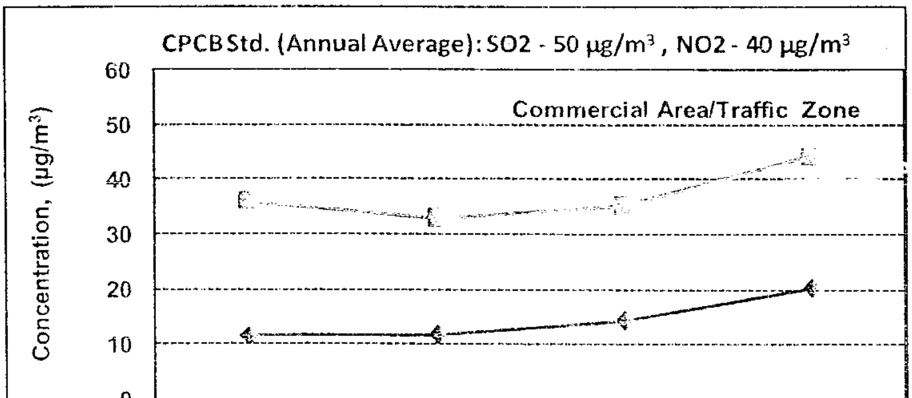


	2001	2002	2003	2004	2005	2006	2007	2008
RSPM	115	219	239	282	234	179	174	218
SPM	180	323	350	405	316	244	298	393

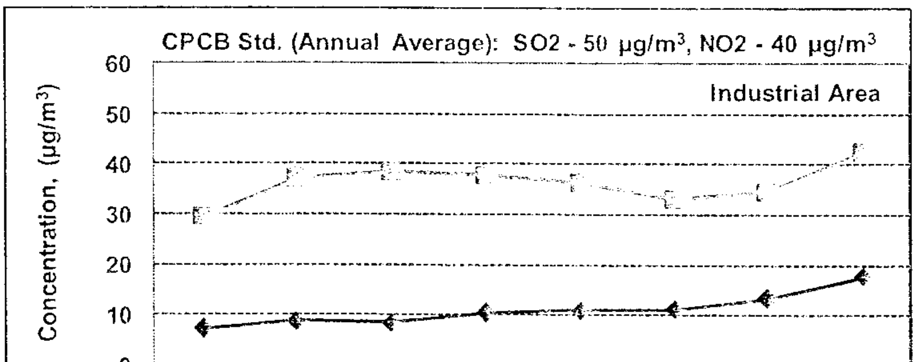
Fig.1.2.1: Annual Average Concentrations of RSPM and SPM in Different Activity Zones (Residential, Commercial & Industrial Areas) of Raipur Region: 2001-2008



	2001	2002	2003	2004	2005	2006	2007	2008
SO2	10	9	8	10	11	12	15	20
NO2	39	35	37	38	36	34	37	45



	2005	2006	2007	2008
SO2	11	11	14	20
NO2	36	33	35	44



	2001	2002	2003	2004	2005	2006	2007	2008
SO2	7	9	8	10	11	11	13	18
NO2	29	37	38	38	36	33	35	42

Fig. 1.2.2: Annual Average Concentrations of SO_2 and NO_2 in Different Activity Zones (Residential, Commercial & Industrial Areas) of Raipur Region: 2001-2008

The major sources of air pollution are observed to be the large number of industries (sponge iron, power, ferro alloys and rolling mills) in the Raipur region. To cater the needs of these industries and also other industries in the State, movement of heavy duty vehicles is tremendous. Apart from these two main sources, combustion of various fuels in household cooking and heating, restaurants & hotels and many other small scale/cottage sectors take place, which ultimately become a part of ambient air pollution. Re-suspension of road dust due to wind movement or resulting due to vehicular movement becomes another source of air pollution.

1.3 Need for the Study

After getting the status of separate State in 2000, Chhattisgarh State has attracted a large number of metallurgical and power industries. Other economic activities have also grown at a faster pace in the State. Raipur, being the capital city, has witnessed exponential development and economic growth. Number of vehicles on roads have also increased manifold in the already congested roads and streets of Raipur. In fact, there is a perception that pollution levels in Raipur city have gone up considerably during the last few years though no definitive studies are available to support this view.

Various types of sources/activities (industrial, vehicular, domestic fuel consumption etc.) are present in the Raipur region. Major air polluting type industries are: Sponge iron units - 39, Captive thermal power plants - 22, Ferro alloy units - 15 and about Induction/ arc furnace units - 65, which fall under red category. Besides, there are more than 150 rolling mills & other units, which fall under orange category. These industries are located mainly in the three industrial areas, namely Siltara, Urla and Borjhara, and their adjoining areas (Gogaon, Gondwara and Sondongri).

Industrial activities at the out-skirt of the city, vehicular conditions and movements, bad conditions of the roads, increase in construction activities etc. are considered to be the main causes of air pollution problem in Raipur region.

In view of the above, Chhattisgarh Environment Conservation Board (CECB), Raipur, was keen to know the contribution of industrial sources to the total air pollution in and around Raipur city to decide on future strategies to deal with the matter of pollution effectively. Therefore, CECB retained National Environmental Engineering Research Institute (NEERI), Nagpur, to carry out a study on assessing the contribution of air polluting industrial sources in the Raipur region (which includes Raipur city and its surrounding industrial areas), so that appropriate remedial measures for improvement in air quality of the region can be taken. The details of the study are given below.

1.3.1 Objective of the Study

The main objective of the study is to assess the contribution of industrial sources on the overall ambient air quality of the region.

1.3.2 Scope of Work

For assessment of the contribution of industrial sources on the overall ambient air quality of the region, the study would include the following:

- Preparation of emission inventory of industrial sources
- Monitoring for major air pollutants in the study region
- Stack emission characterization in representative industries
- Air quality modelling and source contribution assessment analysis
- Delineation of air quality management plans for overall improvement in air quality of the region.

The details of scope of work are as follows:

(a) Preparation of detailed emission inventory for industrial sources in the Raipur region, that will include:

- A comprehensive emission inventory for all the major industrial sources, which would include details of industries, their locations, fuel consumption, raw material inputs, products, waste generation, stack details and emission characteristics etc.

- Stack emission monitoring of Particulate Matter in selected/representative industries particularly iron & steel industries including sponge iron plant, coal/coal char & dolo-char based power plants

- Collection of secondary data on meteorological parameters for dispersion modeling

- Collection of site-specific micro-meteorological data with respect to wind speed, wind direction, relative humidity, ambient temperature etc. One meteorological station would be installed in the region during the study period

(b) Stack emission characterization in representative industries of the Raipur region

(c) Monitoring of ambient air quality with respect to SPM, PM_{10}, SO_2, NO_2, CO and HC at selected receptor locations of the Raipur region. This will include:

- Ambient air quality (AAQ) monitoring at 5-6 representative sites (representing residential, commercial, industrial and sensitive/ reference areas) in the study region continuously for 07 days during one season (winter/summer). The season winter/summer would be selected in such a way that the study undertaken would be of representative nature in all environmental aspects, as decided jointly

- The sampling duration would be of 8 hours each during the 24 hrs cycle. The analysis would be in accordance with the standard methods as prescribed by the CPCB

(d) Source contribution assessment based on dispersion modeling and receptor modeling. This will include:

- Assessment of impacts of industrial sources on ambient air quality using appropriate air quality models and estimation of contribution of industrial sources at selected receptors with respect to Particulate Matter
- Preparation of iso-concentration plots on the study region map
- Chemical (elemental and ionic) characterization of ambient PM_{10} and stack particulate matter would be carried out to identify chemical species for different types of industrial sources present in the region through receptor modeling

(e) Data analysis and interpretation for estimation and assessment of the contribution of industrial sources on the overall ambient air quality of the region

(f) Delineating air quality management plans/mitigation measures based on the estimation and assessment of the contribution of industrial sources on the overall ambient air quality of the region. Assessment for best possible scenarios for future developmental activities in the region

(g) Report preparation

(h) Training of scientific staff of CECB regarding monitoring/analysis and suggestions regarding strengthening of laboratory of CECB.

The study area will include Raipur region of about 142 km^2, comprising of different industrial areas, viz. Siltara, Borjhara and Urla. The Gogaon, Gondwara and Sondongri etc. areas having industrial activities adjoining to the existing industrial areas would also be included in the study region.

The study has been conducted as envisaged, and the findings are presented in the following Chapters:

Chapter 2: Industrial base of the Region

Chapter 3: Air Quality Status of Raipur Region

Chapter 4: Stack Emission Characterization

Chapter 5: Industrial Source Contribution Assessment

Chapter 6: Strategy for Air Quality Management

Chapter 7: Summary of Study Findings and Recommendations

Chapter 2

Industrial base of the Region

Chapter 2

Industrial base of the Region

2.1 General

Chhattisgarh is generously bestowed with natural resources like forests, minerals and surface water. Till yesteryears - the State has undergone a radical change and is thriving with industrial activities now. Chhattisgarh is producing approximately 20% of steel and 15% of cement in the country. Many Government of India undertakings like Bhilai Steel Plant, National Mineral Development Corporation, South-Eastern Coal Field Limited, NTPC and a number of large cement plants belonging to groups like ACC, Gujarat Ambuja, Grasim, L&T, CCI and La-farge of France and many steel projects (sponge iron/pig iron route) in private sector are also under different stages of implementation.

There are number of steel re-rolling mills, mini steel plants, ferro-alloy units, steel/cast iron casting units, engineering and fabrication units apart from large number of agro based and food processing, chemical, plastic, constructions material, forest produce based units. Of these, many industries are housed in Raipur region, comprising of two main industrial areas at Urla and Siltara, and their adjoining areas.

2.1.1 Present Study Area – Raipur Region

The area for the present study comprises of Raipur region (about 142 km^2), comprises of Siltara, Borjhara and Urla industrial areas. The Gogaon, Gondwara, Sondongri, Borjhara, Tenduwa, etc. areas having industrial activities adjoining to the existing industrial areas are also included in the study region.

The study area land use map with 5 km and 10 km radius marked on it is depicted in **Plate 2.1.1**. Bajrang industry located in the Borjhara-Urla industrial area is taken as the centre.

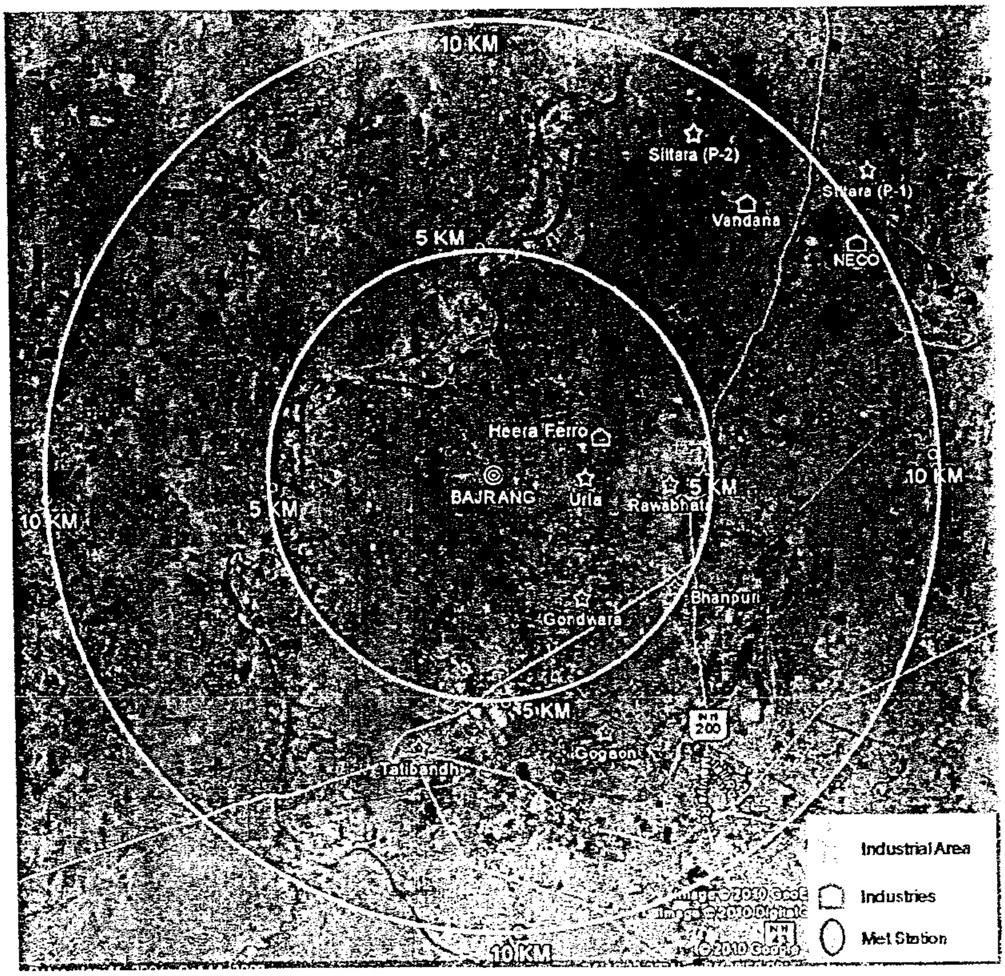


Plate 2.1.1: Study Area Land use Map with 5 km and 10 km Radius Marked

The details of industrial areas in Raipur region are summarized in **Tables 2.1.1 to 2.1.3** for Siltara, Urla and Bhanpuri & Rawabhata, respectively.

Table 2.1.1: Land use of Siltara Industrial Areas - Phase I & II

Land use	Phase I		Phase II	
	Area (hectare)	Area (%)	Area (hectare)	Area (%)
Total Area	736.83	100.00	396.20	100.00
Industrial Plots	622.17	84.44	229.67	57.99
Roads	25.85	3.51	67.22	16.96
Amenities	13.85	1.88	27.83	7.02
Open/Cut off land/ Parking/ Landscaping/ Plantation in quarried area	74.96	10.17	48.44	12.22
Power Sub-station	-		23.04	5.81

(1 hectare = 2.47 acres)

Table 2.1.2: Land use of Urla Industrial Area with Extensions

Land use	Urla Industrial Area+		Urla Industrial Area Extension			
			Borjhara*		Tenduwa	
	Area (acres)	Area (%)	Area (acres)	Area (%)	Area (acres)	Area (%)
Total Area	825.94	100.00	49.81	100.00	25.05	100.00
Industrial Plots	535.54	64.84	28.64	57.50	10.34	41.27
Roads	139.30	16.86	11.20	22.49	7.22	28.82
Amenities	24.50	2.97	1.76	3.53	0.90	3.60
Open/Cut off land/ tanks/ parking	70.67	8.56	3.30	6.63	6.59	26.31
Green belt/Plantations	9.93	1.20			--	--
Housing Colony	46.00	5.57	--	--	--	--
Power sub-station	--	--	0.225	0.45	--	--

\+ including pheripherial industrial areas of Sarora, Sondongri, Gondwara, Gogaon
*Near Saraswati Vidyut & Bajrang Power & (KH 101 & 103)

Table 2.1.3: Land use of Bhanpuri and Rawabhata Industrial Areas

Land use	Bhanpuri		Rawabhata	
	Area (acres)	Area (%)	Area (acres)	Area (%)
Total Area	406.00	100.00	91.88	100.00
Industrial Plots	255.72	63.00	70.24	76.46
Roads	20.16	4.97	17.16	18.68
Amenities	--	--	4.48	4.88
Open/Cut off land/parking/ Plantations	130.12	32.03	--	--

(Source: CSIDC Land use Maps)

Siltara and Urla are the two major industrial areas, housing mainly sponge iron, power, ferro alloy industries and rolling mills, besides many other industries. Salient features of the major industrial areas are as follows:

2.1.2 Siltara Industrial Area

Siltara industrial area is situated at about 13 km away from Raipur. The region has an overall investment of Rs. 716 Crore in various projects that include sponge iron, power and ferro alloys units as major industrial production. Around 48 industries are established in an area of about 1,185 ha, with direct employment to nearly 2,800 persons. Siltara also houses a green belt with more than 1,00,000 trees along the road sides. The major products that roll out from the region include sponge iron, pig iron, power, HR coils, plywood, different chemicals and acids. M/s Jayaswal's Neco Ltd., an Integrated Steel Plant (Blast furnace route) with investment of about Rs. 4000 Crore is located in the area. Land use map of Silatra industrial area is shown in **Fig. 2.1.1**.

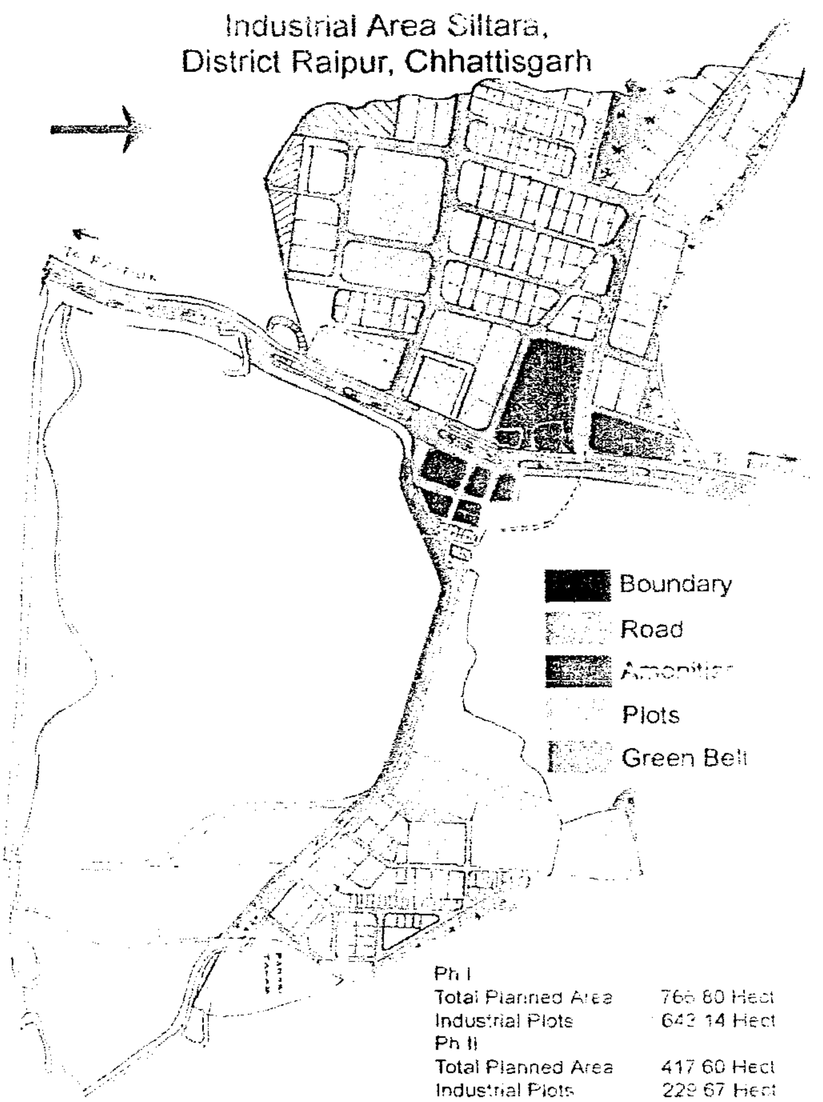


Fig. 2.1.1: Land use Map of Siltara Industrial Area

2.1.3 Urla Industrial Area

Urla Industrial Area is situated on the outskirts of Raipur city on NH 200. It is spread over an area of approx. 375 hectares including peripheral industrial areas of Sorora, Sondongri, Gondwara, Gogaon. Borjhara and Tenduwa are other adjacent industrial areas.

Around 418 Industries are already established with fixed investment of more than Rs. 425 Crores, providing direct employment to nearly 11,300 persons. It has about 33.65 km asphalted roads and 1.24 km WBM roads. The land use map of Urla industrial area is shown in Fig. 2.1.2.

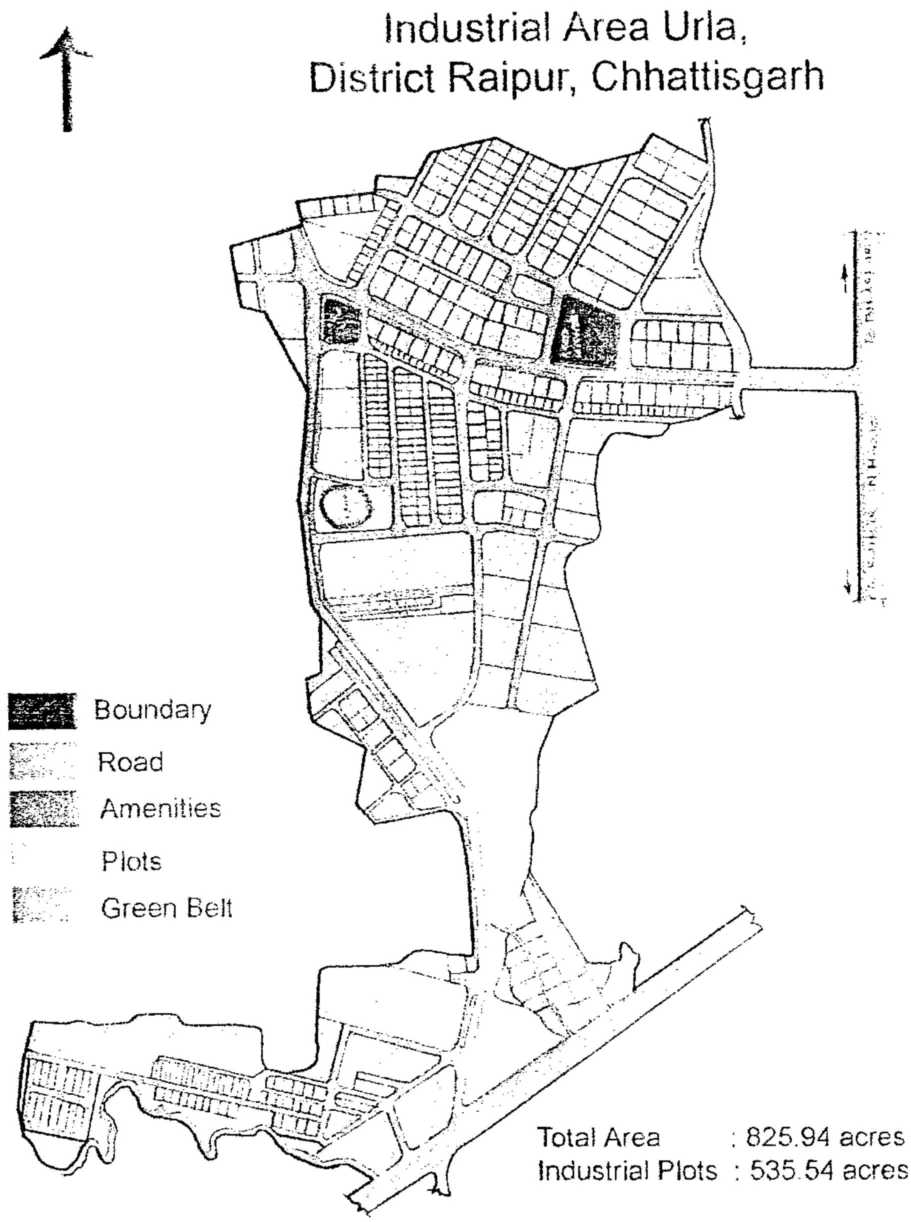


Fig. 2.1.2: Land use Map of Urla Industrial Area

A wide variety of products are manufactured in Urla Industrial Area, which are given in **Table 2.1.4**.

Table 2.1.4: Products Manufactured in Urla Industrial Area

Product Category	Products Manufactured
Metallurgical	Grinding media balls, M.G. casting & Malleable castings, Steel Castings, Special Alloy Castings, Steel Fabrication, Transmission Tower Structures, Ferro Alloys, Re-rolled products, Steel Ingots, HR Strips & Coils, Steel Structurals, Forging, Barbed Wire, Nuts & Bolts, Gear Box, Cutting Tools, Wire Nails, Submersible pumps.
Food	Rice Bran Oil, Flour-Sooji-Maida, Refined Vegetable Oil, Solvent Extraction, Biscuits & Bakery Products, Soft Drinks, Cold Storage, Rice Mill, Edible Oil, Confectionery.
Chemicals	Nitrogen Gas, Oxygen Gas, Carbon di-oxide, Latex Hand Gloves Surgical, H.D.P.E. woven sacks, Tarpaulin, Thermit Welding Powder, Welding Electrodes, Rigid PVC Pipes, Moulded Plastic Products, Rubber Foam, H.D.P.E. Pipes, Paints, Ammonium Nitrate, Sodium Silicate, Chlorinated Paraffin Wax, PVC Shoes, Ferric Alum, Fertilizers, Insecticides, Pesticides, Polythene bags & Sheets, Plastic Lamination, Coal Tar Products.
Miscellaneous Items	Aluminium Structurals, Insulated wire, Carbon Brush, Magnetite, Aluminium Utensils, Aluminium Conductors & Cable, Aluminium ingots, Sheets & Circles, Super Enamelled Copper Wire. Transformer, Batteries. Plywood, Panel Door, Wooden Panel, Veen ears, R.C.C. Hume Pipes, Mosaic Tiles, Stone Polishing. R.C.C. Hume Steel Pipe "T" chest-wooden, A.C. Pressure pipes Cement Products. Conveyor Belt, Tyre Retreading, Offset Printing, corrugated box. Woollen & Silk Blended Yarn & Suiting, Jute Cloth & Rope.

2.1.4 Rawabhata Industrial Area

The Industrial Area of Rawabhata spans over 200 ha, and the region is fairly developed. Around 14.5 km road is asphalted with the surface drains measuring up to 11 km length. The region houses a number of small scale industries from which a wide variety of products roll out. Some of the products include:

Grinding media balls, Malleable castings, Steel Castings, Special Alloy Castings, Steel Fabrication, Transmission Tower Structures, Ferro Alloys, Re-rolled products, HR Strips & Coils, Barbed Wire, Nuts & Bolts, Gear Box, Wire Nails, Submersible pumps.

Rice Bran Oil, Refined Vegetable Oil, Solvent Extraction, Biscuits & Bakery Products, Cold Storage, Rice Mill. Oxygen Gas, Carbon di-oxide, H.D.P.E. woven sacks, Tarpaulin, Welding Electrodes, Rigid PVC Pipes, Paints, PVC Shoes, Pesticides, Plastic Lamination, Coal Tar Products. Plywood, Panel Door, Wooden Panel, Veen ears, R.C.C. Hume Pipes, Mosaic Tiles, Stone Polishing. R.C.C. Hume Steel Pipe, Cement Products.

2.2 Major Air Polluting Industries

Among the various types of industries, major air polluting type industries include Sponge iron units, Thermal power plants (mainly captive), Ferro alloy units and Induction/arc furnace units, which fall under red category. Besides, there are large number of rolling mills, which fall under orange category. These industries are located mainly in the three industrial areas, namely Siltara, Urla and Borjhara, and their adjoining areas (Gogaon, Gondwara and Sondongri). Geographical distribution of these air polluting industries is given in **Table 2.2.1**.

Table 2.2.1: Geographical Distribution of Various Types of Air Polluting Industries in Raipur Region

Industrial Area	Sponge Iron Plants	Captive Power (with Sponge Iron) Plants	Ferro Alloy Units	Rolling Mills	Total
Siltara	32	11	-	10	53
Urla & Borjhara	5	3	11	55	74
Tatibandh	--	--	--	11	11
Rawabhata	--	--	--	11	11
Sondongri	--	--	--	11	11
Sarora	1	--	--	13	14
Sankra	--	--	--	2	2
Gogaon	--	--	--	5	5
Acholi	1			6	7
Gondwara	--	--	--	4	4
Bhanpuri	--	--	--	4	4
Tendua	--	--	--	3	3
Chandnideeh	--	--	--	2	2
Others	--	--	--	13	13
Total	**39**	**14**	**11**	**150**	**214**

(Source: CECB, Raipur)

Siltara industrial area houses 53 major air polluting industries, of which 32 are sponge iron, 11 captive power plants and 10 rolling mills. Another, major industrial area, Urla (including Borjhara) houses 74 industries, of which 55 are rolling mills, 11 ferro alloy units, 5 sponge iron plants and 3 power plants. Other industrial areas have mainly rolling mills and induction furnaces. In all, there are more than 60 induction furnaces in the study region.

List of major air polluting industries (sponge iron, power plants, ferro alloys, rolling mills and induction furnaces) located mainly in Sitara & Urla industrial areas and their adjoining areas is given in **Annexure B (Tables B.2.1 to B.2.4)**.

2.3 Collection and Analysis of Industry Data

In order to understand the magnitude of air pollution generation, basic information/data related to different industries was collected. For the purpose, a specific questionnaire incorporating details with respect to plant, stack characteristics, and environmental management practices adopted by different industries, was prepared. The questionnaire as given in **Form 2.3.1**, was circulated to all the air polluting industries in the region through CECB, Raipur. Initially, limited response was received. Subsequently, the industry specific information/data was collected by visiting industries in person. Efforts were made to cover all the Sponge iron, Power and Ferro alloy plants with a few rolling mills. Data collected from the industries are summarized in **Tables 2.3.1 to 2.3.6**.

2.3.1 Industrial Production and Fuel Consumption Details

The information/data collected/received from various types and capacity industries (totalling 30) has been analysed. Details of these industries with respect to their date of commissioning, investment incurred, installed and production capacity, working days, operating hours in a day and employment status is summarized in **Table 2.3.1**.

Details of input raw materials, boilers, heaters, furnaces with fuel consumption and fuel characteristics are summarized in **Table 2.3.2**.

2.3.2 Sources of Air Pollution - Stack Details

Details of stacks with respect to material of construction, height, diameter, flue gas velocity and volumetric flow rate along with pollution control system installed are summarized in **Table 2.3.3**. This information has been used in estimating total emissions from industries, and is described in Chapter 5.

2.3.3 Sources of Air Pollution - Fugitive Emissions

Apart from the process emissions released through the stacks, there are number of non-point sources of air pollution, known as fugitive emissions. Sources of fugitive emissions include handling, transportation and storage of various input raw materials, intermediate and finished products, lifting of dust due to movement of vehicles in the factory premises etc. Various sources of fugitive emissions are identified in the industries and information / data was collected through questionnaire. Industry-wise information/data on fugitive emission sources is presented in **Table 2.3.4**

Since movement of vehicles on roads results in re-suspension of road dust, leading to dust pollution, therefore, status of roads (approach road and inplant roads) along with details on movement of vehicles was also collected. Industry-wise data/information is presented in Table 2.3.5.

Form 2.3.1

National Environmental Engineering Research Institute, Nehru Marg, Nagpur

"Questionnaire Form for Survey of Industries in Raipur Region for the CECB, Raipur Sponsored Project"

Name of the Industry: ______________________

Type of the Industry: ______________________

Contact Person: ______________________

Address : ______________________

Tel.: ______________ **Mobile:** ______________

Fax : ______________ **Email :** ______________

Sl.	Particular	Response
A.	**Plant Details**	
1.	Date of commissioning of plant	
2.	Capital investment made (Rs. In crores)	
3.	Annual installed capacity, (MT)	
4.	Products with daily production, (MT/ day)	
5.	No. of working days in a year	
6.	Raw material used in production	
7.	Quantity of input materials (MT/ day)	
8.	Total No. of employees	Regular: Contractual:
9.	Working hours in a day and timings	
10.	No. of Boilers & Capacity Type and quantity of fuel used in each Boiler (MT/ day)	
11.	No. of Heaters & Capacity Type and quantity of fuel used in each Heater (MT/ day)	
12.	No. of Furnaces & Capacity Type and quantity of fuel used in each Furnace (MT/ day)	
13	Total quantity of fuel used in the plant (Coal, LDO,LSHS, Furnace Oil etc. (MT/ day or KL/ day) Fuel-wise details	
14.	Fuel characteristics for each type of fuel (Ash, Fixed Carbon, Volatile Matter, Nitrogen, Sulpher content etc.); Grade of Coal used	

B.	**Stack Details and Flue Gas Characteristics**	(Please use additional sheet, if required)			
15.	No. of Stacks				
	(Please provide information for each Stack)	**Stack 1**	**Stack 2**	**Stack 3**	**Stack n**
16.	Stack attached to the unit				
17.	Capacity of the each process unit				
18.	Raw material consumption in each unit (ore etc.)				
19.	Fuel consumption in each unit (coal, FO etc.)				
20.	Natural draft/ ID Fan/ FD Fan & Fan Capacity, (Nm^3/hr)				
21.	Material of construction of each stack				
22.	Height of each stack above ground level, (m)				
23.	Height of each stack above factory roof, (m)				
24.	Height of port hole for stack monitoring, (m)				
25.	Top diameter of each stack, (m)				
26.	Flue gas temperature, (°C)				
27.	Flue gas velocity, (m/s)				
28.	Volumetric flow rate of flue gas, (Nm^3/hr)				
29.	Pollutant Concentration in flue gas, (mg/Nm^3)				
	a. Particulate Matter				
	b. Sulfur Dioxide				
	c. Nitrogen Dioxide				
30.	Air pollution control equipment installed, Type and Date of Installation				
31.	Reduction efficiency achieved, %				
32.	Stack Coordinates, Latitude (N)				
	Longitude (E)				
	Height above MSL (m)				

C.	Others	
32.	Status of Stack and Ambient Monitoring (Please provide a copy of report submitted to CECB)	
33.	Type of entrance road to factory from main road and its length	Cemented/tarred/Unpaved & its Length
34.	Total length of motorable roads in factory premises, (km)	Cemented/tarred: Unpaved:
35.	Number of trucks moving inside the plant premises per day	
36.	Total distance traveled within factory premises by all types of heavy duty vehicles (trucks, tractors, dumpers, crane etc.), km	
37.	Activities/Factors contributing to fugitive emissions within premises (tick appropriate one) a. Unloading of coal/ore/ raw materials; b. Ash disposal; c. Brick making d. Disposal of solid waste; e. Downloading of solid waste below ESPs/ bag f. Flters/cyclones etc.; g. Truck/dumper movement h. Barren/uncovered soil blown by wind/ vehicles i. Packaging of products j. Solid fuel/raw material handling/ transportation/charging; k. Any other	
38.	Effects for controlling air/water/solid waste pollution (please use separate sheet for details)	
39.	Type and Number of trees planted within & around factory premises	
40.	Total factory area and area covered under plantation, (ha)	
41.	Type & Quantity of waste water produced (KL/day)	
42.	Arrangement for waste water treatment and disposal	
43.	Type & Quantity of solid waste (ton/day)	
44.	Quantity of recyclable or reusable solid waste	
45.	Treatment and disposal of solid waste	
46.	Direction & distance of plant with respect to Raipur (Jaistambh Chowk)	

Please provide a copy of plant layout with location of stacks marked on it. Also indicate the distance & direction between stacks/chimneys with respect to the tallest stack.

Signature of the contact person (optional)

2.3.4 Environmental Management Practices Adopted

In order to mitigate air pollution generated in the manufacture of sponge iron, power, ferro alloy and metal products, the respective industries have their own environmental management system. For control of emissions through stacks, all the sponge iron and power plants are equipped with Waste Heat Recovery Boiler (WHRB system) and Electro-Static-Precipitator (ESP). Ferro alloy industries are equipped with bag filters/cyclone scrubbers. In general, Rolling mills have installed settling chamber or cyclone scrubber. Apart from point sources, substantial amount of dust is generated through non-point sources, which can mainly be arrested through green belt development. Therefore, details of plantation, solid waste generation, wastewater utilization are also collected. The information provided by the industries in presented in **Table 2.3.6**.

Table 2.3.1: Production Details of Industries in Raipur Region

Sr. No.	Industry	Date of Commissioning	Investment	Annual Installed Capacity	Products with Daily Production (MT/day)	Working Days	Total Employees	
							Regular	Contract
	Silatra Industrial Area							
1.	Sarda Energy and Minerals Ltd.	SIP- 1993, 1996, Jan 2005, Jan 2008 IF- Dec 2001, Oct 2006, Dec 2008 PP- Nov 2001, May 2002, Jan 2005, Jan 2008, April 2009 FA- Nov 2001, Jul 2006	459 Cr	SIP- 460 K TPA IF- 360 K TPA PP- 61.5 MW FA- 90 K TPA	Sponge iron- 534TPD Rolling Mill Steel Ingot & Billet- 229.30 TPD Power- 45 MW FA- 177.84 TPD	320-330	888	637
2.	Godawari Power & Ispat	SIP- Apr 2001	436.47 Cr	SIP- 495 K TPA, Steel Billet- 400 K TPA, PP- 53 MW, Ferro Alloy- 16.5 K TPA, HB Wire- 100 K TPA, O_2- 12x10^5 m^3/A, N- 45000 m^3/A, Fly Ash Brick- 165x10^5 Nos./A	SIP - 1500 TPD, Billet - 1212 TPD	330	905	175
3.	Vandana Global Pvt. Ltd.	2001- Phase I 2007-Phase II	198 Cr	SIP- 231 K TPA PP- 38 MW Rolling Mill- Billet 150K TPA	Sponge iron- 700 TPD Power- 38 MW Rolling Mill- 454 TPD	330	740	100-200
4.	S.K.S. Ispat Pvt. Ltd.	SIP: Mar 2005 PP Sep 2007 Rolling Mill: Oct 2005 Ferro: Mar 2008	550 Cr	SIP- 270 K TPA PP- 30 MW Rolling Mill- 384 K TPA Ferro- 29.4 K TPA	Sponge iron- 900 TPD Power - 30 MW Rolling Mill -1200 TPD Ferro - 90 TPD	300 350 300 330	855	1455
5.	Droliya Electrosteels Pvt. Ltd.	SIP- Apr 2004 Steel- Oct 2006	SIP- 18.33 Cr, Steel- 18.54 Cr	SIP- 66 K TPA Steel- 66 K TPA	SIP- 200 TPD MS Billets- 200 TPD	330	205	245

Table 2.3.1 (Contd...): Production Details of Industries in Raipur Region

Sr. No.	Industry	Date of Commissioning	Investment	Annual Installed Capacity	Products with Daily Production (MT/day)	Working Days	Total Employees	
							Regular	Contract
6.	Mahendra Sponge and Power Pvt. Ltd.	Dec 2003 Nov 2004 Mar 2007	56.72 Cr	SIP- 60 K TPA Power- 8 MW	Sponge iron- 200 TPD	365	224	33
7.	N.R. Sponge Pvt. Ltd.	SIP- Feb 06 PP- Apr 06 IF- Apr 06	53.88 Cr	SIP- 60 K TPA PP- 12 MW IF- 36 K TPA	Sponge iron- 200 TPD Billets- 120 TPD	300	265	60
8.	Shree Nakoda Ispat Pvt. Ltd.	SIP- Aug 04 PP- Dec 05 & Jan 09 Rolling- Jan 06	88.81 Cr	SIP- 66 K TPA PP- 6MW, 5MW Rolling Mill- 115.2 K TPA	Sponge iron- 200 TPD Power- 11 MW Rolling Mill- 384 TPD	300	140	90
9.	Baldev Alloys Pvt. Ltd	Aug 17, 2004	38 Cr	SIP 50 x 4 TPD Arc Furnace = 30 K TPA, Power – 8 MW (Under Cons.)	SIP 50 x 3	300	70	40
10.	SK Sarawagi & Co. Pvt. Ltd.	Dec 2004	50 Cr	DRI- 60 K TPA MS Ingot & Billet- 57.6 K TPA Rolling Mill- 54 K TPA	DRI- 200 TPD MS Ingot & Billet- 160 TPD Rolling Mill- 150 TPD	300	250	200
11	Rashmi Sponge Iron Pvt. Ltd.	Oct 2004	88.43 Cr	SIP - 66 K TPA, MS Ingot – 100 K TPA, Power – 8 MW	SIP – 200 TPD, MS Ingot – 300 TPD, Power – 8 MW	300	160	Nil
12.	Aarti Sponge & Power Ltd.	Feb 2005 Jan 2006	N.A	60 K TPA 48 K TPA	Sponge iron -120 TPD, IF-100 TPD	300	90	60
13.	Shree P.D. Industries Ltd.	March 2005	48.94 Cr	SIP - 90 K TPA, MS Ingot & Billets – 50.4 K TPA, Power – 8 MW	SIP – 300 TPD MS Ingot & Billets – 150 TPD, Power – 8 MW	300	190	500
14.	Agrawal Sponge Iron Ltd.	Mar 2003	24.46 Cr	SIP- 60 KTPA, MS Ingots- 18 K TPA	Sponge iron, MS Ingots	365	80	20

Table 2.3.1 (Contd...): Production Details of Industries in Raipur Region

Sr. No.	Industry	Date of Commissioning	Investment	Annual Installed Capacity	Products with Daily Production (MT/day)	Working Days	Total Employees	
							Regular	Contract
15.	G.R. Sponge & Power Ltd.	Feb 2004 Sept 2005	44 Cr	2x36.75 K TPA	Sponge iron-140 TPD for both	365	48	15
16.	Ghankun Steels Pvt. Ltd	N.A	13.5 Cr	MS Ingot- 18 K TPA SIP- 75 K TPA	MS Ingot- 60 TPD SIP- 250 TPD	365	73	61
17.	Devi Iron and Power Pvt. Ltd.	June 2009	24 Cr	SIP – 90 K TPA	SIP – 300 (3x100) TPD	300	259	50
18.	Abhijeet Infrastructure	Aug 2006	100.31 Cr	120 KTPA	DRI- 350 TPD	360	59	30
19.	Vaswani Industries Ltd.	Aug 2004	25.51 Cr	SIP – 99 K TPA, Power – 6 MW	SIP – 300 TPD, Power – 6 MW	300	80	40
20.	Euro Pratik Ispat Pvt. Ltd.	Apr 2005	11 Cr	30 K TPA	60-80 TPD	300	36	30
21.	Bhagwali Power & Steel Ltd	Jan 2006	27.98 Cr	60 K TPA	Sponge iron- 2x100 TPD	300	100	18
22.	API Ispat & Powertech Ltd.	SIP- June 2006	85.5 Cr	SIP- 105 K TPA	Sponge iron- 227 TPD	300	108	148
		CPP 8 MW- Jun 2007 CPP 7 MW- Oct 2008		CPP- 15 MW	CPP- 15 MW	300 355		
		IF-CC Shop- Oct 2008		Steel Billets- 43.2 K TPA	Billets- 78.3 TPD	300		
23.	Trimula Sponge Iron Pvt. Ltd.	March 2005	42.49 Cr	SIP – 66 K TPA, MS Ingot & Billets – 66 K TPA, Power – 8 MW	Sponge iron- 100 TPD, Billets	300	150	40
24.	Corporate Ispat and Alloys Ltd.	Oct 2007	111.65 Cr	175 K TPA	DRI- 500 TPD	350	132	35
25.	Maa Usha Urja Ltd.	Apr 2007	2.34 Cr	7.5 MW	7.5 MW	350	51	Nil
26.	Sunil Sponge Pvt. Ltd.	Sept 2005	25 Cr	SIP – 60 K TPA	Sponge iron – 200 TPD	300	82	25
27.	Jagadamba Power & Alloys Ltd.	Mar 2007	N.A	25 MW	25 MW	330	26	120

Table 2.3.1 (Contd...): Production Details of Industries in Raipur Region

Sr. No.	Industry	Date of Commissioning	Investment	Annual Installed Capacity	Products with Daily Production (MT/day)	Working Days	Total Employees	
							Regular	Contract
	Urla industrial Area							
28.	Jayaswal Neco Ind. Ltd.	Blast Furnace & PP- Nov 96 Sinter- Nov 04	Blast Furnace & PP- 184 Cr Sinter: 41.09 Cr	Blast Furnace- 650 K TPA, Power- 21 MW Sinter- 864 K TPA	Pig Iron- 1800 TPD Power- 21 MW Sinter- 2400 TPD	360	1536	Nil
29.	Satyarth Steel & Power Pvt. Ltd.	Nov 2002	11.96 Cr	30 K TPA	45 TPD	300	32	42
30.	Shree Sita Ispat & Power Pvt. Ltd	Apr 2004	24 Cr	30 K TPA	40 TPD	365	185	45
31.	Real Ispat and Power Pvt. Ltd.	SIP- Feb 2006 PP- Apr 2006 IF- Apr 2008	53.88 Cr	SIP- 60 K TPA PP- 12 MW IF- 36 K TPA	Sponge iron- 200 TPD Billets- 120 TPD	300	265	60
32.	Shilpy Steels Pvt. Ltd.	Dec 2004	3 Cr	15 K TPA	30 TPD	250	55	12
33.	Raghuveer Ferro Alloys	June 1990	6.68 Cr	15.9 K TPA	50 TPD	300	89	N.A
34.	Srinivasa Ferro Alloys	Jun 1989	2.63 Cr	10 K TPA	25-30 TPD	300	42	44
35.	Sri Girija Smelters Ltd.	Feb 1989	7.43 Cr	15 K TPA	35-40 TPD	300	37	78
36.	Hira Ferro Alloys Ltd.	Unit II- Aug 2006 Unit I- Oct 1990 Unit II- Sep 1993	58.04 Cr 33.29 Cr 6.48 Cr	20 MW 10.5 K TPA 50 K TPA	PF · 20 MW F/ - 20 TPD Si Mn- 59.54 TPD	330 330 330	74 35 117	85 40 58
37.	Indsil Energy and Electrochemicals Ltd.	Mar 2005	33.67 Cr	11 MW	1· .833 MW	340	36	32
38.	Deepak Ferro Alloys	Feb 1988	1.5 Cr	12 K TPA	2 ·-30 TPD	300	100	150
39.	Alok Ferro Alloys Ltd.	FA-1995 PP- Feb 2006	7.14 Cr 21.32 Cr	12 K TPA 8 MW	6 5 TPD · MW	330 330	N.A N.A	N.A N.A

Table 2.3.1 (Contd...): Production Details of Industries in Raipur Region

Sr. No.	Industry	Date of Commissioning	Investment	Annual Installed Capacity	Products with Daily Production (MT/day)	Working Days	Total Employees	
							Regular	Contract
40.	Monnet Ispat & Energy Pvt. Ltd	April 1991	3.7 Cr	Ferro alloy – 15 K TPA	Ferro alloy – 35 TPD	300	52	50
41.	R.R. Ispat Ltd.	April 2002	16 Cr	100 K TPA	N.A.	300	100	60
42.	Hira Steel Ltd.	Jan 1997	15.93 Cr	120 K TPA	N.A.	N.A.	N.A.	N.A.
43.	Alankar Steels	Feb 2001	420.24 Cr	IF- 25 K TPA, Rolling mill – 19.5 K TPA	19.5-25 KTPD	300	8	60
44	Hira Power & Steels	May 2009	15 Cr	Silico Manganese – 90 K TPA Ferro Manganese – 90 K TPA	Silico Manganese – 30 TPD Ferro Manganese – 30 TPD	330	25	10

Table 2.3.2: Raw Material Input Requirements with Fuel Characteristics in Major Industries

Sr. No.	Industry	Raw Materials & Quantity	No. of Boilers & Capacity	Fuel Used in each Boiler	No. of Furnace, Type & Quantity	Total Quantity of Fuel used	Fuel Characteristics
	Siltara Industrial Area						
1.	Sarda Energy and Minerals Ltd.	SIP: Iron Ore (324.5 KTPD), Coal (283.2 KTPD), Dolomite (5.4KTPD), LDO (106.8 KL) Power: Coal (275.7 KTPD), Dolochar (0.479 KTPD), Salt (0.64KTPD), Caustic Soda (0.098 KTPD), HCL (0.237 KTPD), Bed material (0.095KTPD) Rolling Mill: Sponge Iron (72 KTPD), Pig/Cast Iron (0.188 KTPD), Scrap(13.7 KTPD), Silico Mn (0.88 KTPD), Ferro Mn (0.235 KTPD)	(7) WHRB (2x9 TPH) WHRB (2X53.2 TPH) AFBC (2X90 TPH) AFBC (1X90 TPH)	Coal (2X415 TPD)	SIP 2X100 TPD 2X500 TPD Ferro Alloy 5X9 mV A	Coal- 558.9 KTPD LDO 0.33 KL/D	Ash: 27-32%, VM: 27-28%, FC: 37-48%, Moisture: 9-12%, S: 0.3%, GCV: 3800 Kcal/kg
2.	Godawari Power & Ispat	Iron Ore , Coal, Dolomite, Sponge Iron, Pig Iron, Scrap,	AFBC (70 TPH) WHRB (30 TPH) WHRB (56 TPH) WHRB (2X51 TPH)	AFBC (350 TPD)	(11) 1&2- 6T, 3,4,&5- 7T, 6,7&8- 12T 9&10- 15T, Arc Furnace- 9MV	2100 TPD	Ash: 40-44%, VM: 22-23%, FC: 32-36%, Moisture: 6-8%, GCV: 3600-4000 Kcal
3.	Vandana Global Pvt. Ltd.	SIP: Coal (960 TPD) Iron ore (591 TPD), Mn ore (80 TPD), Dolomite (22.5 TPD),	(4) AFBC (2X90 TPH) WHRB (30 TPH) WHRB (55 TPH)	Coal	(3) IF- (2x6 T), (2x12 T), Submerged arc furnace ([illegible]x9mVA) Electric charged	Coal- 960TPD LDO- 50KL/D	Ash: 51%, VM: 23-24%, FC: 24-25%, N: 0.6%, S: 0.5%, F /C/B/A grade coal

Table 2.3.2 (Contd...): Raw Material Input Requirements with Fuel Characteristics in Major Industries

Sr. No.	Industry	Raw Materials & Quantity	No. of Boilers & Capacity	Fuel Used in each Boiler	No. of Furnace, Type & Quantity	Total Quantity of Fuel used	Fuel Characteristics
4.	S.K.S. Ispat Pvt. Ltd.	SIP- Sponge Iron (1.6 TPD), Coal (1.6TPD), Dolomite (30 kg/T) Power - Coal (1.25 T/MW) Rolling Mill: Steel Billets & Blooms Ferro: Mn Ore, Mn Slag, Quartz, Coke	SIP: (4) WHRB 2X100, 2X350 Power: 1X110 TPH AFBC Ferro: 2x9Mva Submerged Arc Furnace	SIP: Coal (1440 TPD) Power: Coal (578TPD), Charcoal (190TPD)	Rolling Mill (3) Billet Reheater Ferro: Submerged Arc Furnace	SIP: 1440 TPD PP: Coal- 600 TPD Char- 200 TPD Rolling: FO-2.66 KL/D Ferro: Coke- 70 TPD	SIP: Coal of B& F grade, S<0.5% Power: Ash: 45%, GCV: 3200- Kcal/kg
5.	Droliya Electrosteels Pvt. Ltd.	Iron Ore, Coal, Dolomite, Sponge Iron, Pig Iron, Scrap, Ferro Alloy, Aluminium, Pet Coke	4 MW WHRB 6 MW AFBC	Coal - 33.3 K TPA, Dolomite – 29.7 K TPA	2X 10 TPD, Electric Charged	Coal- 270 TPD	Ash: 46%, VM: 24%, FC: 30, N: 0.63%, S: 0.58%, F& E grade coal
6.	Mahendra Sponge Iron and Power Pvt. Ltd.	SIP- Iron ore (300 TPD), Coal (3000 TPD), Dolomite(5 TPD), PP- Coal (100)	(3) WHRB (2x10.5 TPH) AFBC (27 TPH)	Coal 100 TPD	1 for AFBC	Coal- 400 TPD	Ash: 38±5%, VM: 27±2%, FC: 33±3%, Moisture: 6-8%, N: 6%, S: 3%, F grade coal
7.	N.R. Sponge Pvt. Ltd.	SIP- Iron ore (300 TPD), Coal (240 TPD), Dolomite (6 TPD) PP- Coal (100 TPD), Dolochar (80 TPD) IF- Sponge iron (112 TPD), Pig Iron (21 TPD), Scrap (3 TPD)	Nil	Nil	2X8 T Electric Charged	Coal- 340 TPD	Coal of F & E grade

Table 2.3.2 (Contd...): Raw Material Input Requirements with Fuel Characteristics in Major Industries

Sr. No.	Industry	Raw Materials & Quantity	No. of Boilers & Capacity	Fuel Used in each Boiler	No. of Furnace, Type & Quantity	Total Quantity of Fuel used	Fuel Characteristics
8.	Sree Nakoda Ispat Ltd.	SIP: Iron Ore (372 TPD), Coal (344 TPD), Dolomite(18 TPD) Power: Coal (40TPD), Paddy Husk(250 TPD) Rolling Mill: Sponge Iron (349 TPD), Pig Iron (50 TPD, Scrap (65 TPD), Silicon Mn (8 T), Ferro Silicon (6 T), CPC (12 TPD)	(2) WHRB (26TPH) CFBC (70 TPH)	Paddy Husk (250 TPD) Coal (40 TPD)	(4) Electric charged 4X10 TPD	Paddy Husk (250 TPD) Coal (40 TPD)	ROM F grade, Steam
9.	Baldev Alloys Pvt. Ltd.	Iron Ore (90 TPD), Coal(85 TPD), Dolomite (2 TPD)	Under cons. -1, AFBC – 10 TPH (2MW), WHRB – 30 TPH (6 MW)	Room coal fired & dolochar	1	1.8 T/MW	ROF grade, CV – 2800 Kcal/kg
10.	S.K. Sarawagi & Co. Pvt. Ltd.	Iron Ore , Coal, Dolomite, Pig Iron, MS Scrap	2x11 TPH WHRB	NIL	(2) (2x8 T) of 80 TPD each	Coal - 300 TPD Furnace oil - 3 KLD	Steam coal B grade. ROM, Washed, F grade coal
11.	Rashmi Sponge Iron Pvt. Ltd.	SIP: Iron Ore (1.8 T/T), Coal (1.6 T/T),Dolomite (0.04 T/T), Steel: Sponge Iron (0.69 T/T), Scraps (0.39 T/T),Ferro Alloy (0.02 T/T), PP: Coal (60 TPD), Dolochar (40TPD)	Nil	Nil	Nil	220 TPD	F grade coal
12.	Aarti Sponge & Power Ltd.	Iron Ore , Coal, Dolomite, Sponge Iron, Scrap	Nil	Nil	2x8 T Electric charged	Coal- 216 T, LDO- 400 litre	E grade (ROM/Steam)
13.	Shree P.D. Industries	MS & CIC scrap – 13263 TPA, Ferro alloy – 504 TPA, Iron ore – 96 K TPA, Lime stone – 600 TPA	Nil	Nil	Nil	Coal 72 K TPA Coal fines & lumps – 32 K TPA	F grade coal

Table 2.3.2 (Contd...): Raw Material Input Requirements with Fuel Characteristics in Major Industries

Sr. No.	Industry	Raw Materials & Quantity	No. of Boilers & Capacity	Fuel Used in each Boiler	No. of Furnace, Type & Quantity	Total Quantity of Fuel used	Fuel Characteristics
14.	Agrawal Sponge Ltd.	Iron Ore , Coal, Dolomite, Sponge Iron, Pig Iron, Scrap	Nil	Nil	(1), Electric charged, 6 T	Coal- 40 TPD	36 F grade coal
15.	G.R. Sponge and Power Ltd.	Iron Ore, Coal	(3) WHRB (2x10 TPH), AFBC (1X27 TPH)	AFBC – 50 TPD char/dolochar	Nil	Coal- 375 TPD	F grade coal
16	Ghankun Steels Pvt. Ltd.	Iron Ore (200 TPD) Coal (250 TPD), Dolomite (5 TPD), Pig Iron, Sponge, Iron Scrap, Ferrosil	(1) 5MW	WHRB	(1) 60 TPD	Coal- 375 TPD	F grade coal
17.	Devi Iron & Power Pvt. Ltd	Iron Ore, Dolomite Total (150 TPD)	Nil	Nil	Nil	Coal- 150 TPD	FC: 26-42%, S: 0.20-0.30%
18.	Abhijeet Infrastructure	Iron Ore, Coal, Dolomite	(2) WHRB- 38 TPH AFBC- 33 TPH	AFBC- 120 TPD	Nil	Nil	Ash: 35-38%, VM: 24-28%, FC:37-40%
19.	Vaswani Industries Ltd.	Iron Ore – 158.4 K TPA, Coal – 1485 K TPA, Dolomite – 3465 MTPA	(2) WHRB- 7.5 MW AFBC- 2.5 MW	N.A.	1 IF- 36 K TPA	Coal – 148.5 K TPA, FO – 990 KL/A	F grade coal
20.	Euro Pratik Ispat Pvt. Ltd.	Iron Ore, Coal	Nil	Nil	Nil	150 TPD	Ash: 40%, VM: 26%, FC: 34%
21.	Bhagwati Power & Steel Ltd	Iron Ore (2X145 TPD), Coal (2X135 TPD), Dolomite (2X4TPD)	Nil	Nil	Nil	Nil	Nil
22.	API Ispat & Powertech Ltd.	Iron Ore, Coal, Dolomite	(2) WHRB- 8 MW AFBC- 7 MW	WHRB- Nil, AFBC- Coal Fines (126 TPD), Char (60 TPD)	(2) DRI- 350 T IF- 12 T	Coal- 416 TPD Furnace Oil- 231 LPD	F grade coal, FC:28-32%, Ash:38-42%, VM:30%
23.	Trimula Sponge Iron Pvt. Ltd.	Iron Ore – 105.6 K TPA, Coal – 79.2 K TPA, Dolomite – 66 K TPA	WHRB – 4 MW AFBC – 4 MW	WHRB – Nil AFBC – 5760 TPA	Nil	Coal - 240 TPD	F grade coal
24.	Corporate Ispat and Alloys Ltd.	Iron Ore, Coal, Dolomite (1520 TPD)	(1) WHRB- 52 TPH	Nil	Nil	Coal- 700 TPD	Ash: 35-38%, VM: 24-28%, FC: 37-40%

Table 2.3.2 (Contd...): Raw Material Input Requirements with Fuel Characteristics in Major Industries

Sr. No.	Industry	Raw Materials & Quantity	No. of Boilers & Capacity	Fuel Used in each Boiler	No. of Furnace, Type & Quantity	Total Quantity of Fuel used	Fuel Characteristics
25.	Maa Usha Urja Ltd.	Coal , Rice Husk	33 TPH	Coal & Rice husk (200 TPD)	Nil	Coal & Rice Husk-Total (200 TPD)	Ash: 35-37%, FC: 27-40%, VM: 24-28%
26.	Sunil Sponge Pvt. Ltd.	Iron Ore, Coal, Dolomite	1 WHRB – 4 MW	WHRB - Nil	IF – 12 MTPA	Coal – 240 TPD	Ash: 25-30%, FC: > 45%, VM: 25-30%
27.	Jagdamba Power & Alloys Ltd.	Coal, Char/Dolochar	AFBC- 105 TPH	750 TPD	NIL	750 TPD	Ash: 50%, VM:20%, FC: 20%, N:0.61%,, S: 0.29%, Moisture: 10%, F grade coal
28.	Jayaswal Neco Ind. Ltd.	Blast Furnace & Power Iron ore, Coke, Dolochar, Coal Dust & BF gas (2700 TPD) Sinter Iron flakes , Coal fines etc. (1600 TPD)	Blast Furnace & Power (4) Oil/gas fired (3X30 TPH) (1xcoal fired)	Blast Furnace & Power $3x25000\ m^3$	(1) $650\ m^3$	Blast Furnace Coke(650 TPD) , Coal Dust(82 TPD), **Power** BF gas- $90000 m^3$ Sinter BF gas- $8000m^3$ Coke Dust (116 TPD)	Ash: 12%, VM:1.5%, FC: 17%, S: 0.6% (good quality coke)
	Borjhara-Urla Industrial Area						
29.	Satyarth Steel & Power Pvt. Ltd.	Iron ore	Nil	Nil	Nil	90 TPD	Ash: 53%, VM-22%, FC: 26%, Moisture 8%, F grade coal
30.	Shree Sita Ispat & Power Pvt. Ltd	Iron ore , coal, dolomite	Nil	Nil	5T Induction	Coal- 80 TPD, Diesel – 200 litre	F grade coal
31.	Real Ispat and Power Pvt. Ltd.	Iron ore , coal, dolomite	(3) AFBC- 1 WHRB- 2	N.A.	(2) 2x8 TPH Electric Charged	Coal- 340 TPD	E & F grade coal
32.	Shilpy Steels Pvt. Ltd.	Iron ore , Coal, Dolomite	Nil	Nil	Nil	Coal- 35 TPD	F grade coal

Table 2.3.2 (Contd...): Raw Material Input Requirements with Fuel Characteristics in Major Industries

Sr. No.	Industry	Raw Materials & Quantity	No. of Boilers & Capacity	Fuel Used in each Boiler	No. of Furnace, Type & Quantity	Total Quantity of Fuel used	Fuel Characteristics
33.	Raghuveer Ferro Alloys, Urla	Iron scrap - 75 MT/month, Quartz – 500 MT/month, Electrode Paste – 20 MT/month, Charcoal – 375 MT/month	Nil	Nil	Nil	Charcoal – 375 MT/month	Slag
34.	Srinivasa Ferro Alloys	Mn Ore, Coke, Fluxes	Nil	Nil	(2) 2x3.6 mVA	Nil	Nil
35.	Sri Girija Smelters Ltd.	Mn Ore, Coke, Fluxes	Nil	Nil	(2) 3.6 mVA & 4.5 mVA	Nil	Nil
36.	Hira Ferro Alloys Ltd.	Unit I- Mn Ore, Coke/Coal, Dolomite, HM Scrap Unit II- Mn Ore, Coal, Dolomite	Electricity Electricity	Nil Nil	(1) 4.5 MW/h (4)	Electricity	Nil
		Coal	(1) 90 TPH	Coal 600 TPD	Nil	Coal- 600 TPD	FC: 14.26%, Ash: 53.30%, VM:23.84%, Moisture: 9%, GCV:2852 Kcal/Kg
37.	Indsil Energy and Electrochemicals Ltd.	ROM Grade Coal	(1) 1x50 TPH	Nil	Nil	Coal 250-280 TPD	FC: 28-31%, VM: 8-10%, GCV:3600-4000 Kcal/Kg
38.	Deepak Ferro Alloys	Mn Ore	Nil	Nil	(2) 3.0 mVA & 4.5 mVA	Electric based furnace	Nil
39.	Alok Ferro Alloys Ltd	Mn Ore Coal/Coke, Dolomite	Electricity	Nil	(2) 2x4 mVA	Nil	FC: 55-70%, Ash: 10-12%, VM: 25-28%
40.	Monnet Ispat & Energy Pvt. Ltd	Coal, Coke, Quartz, Dolomite, Mn Ore	Nil	Nil	1 submerged arc furnace of 7.5 mVA	Coal – 10 TPD Coke –15 TPD	--
41.	R.R. Ispat Ltd.	Billet (254 TPD)	Nil	Nil	([illegible]), 69,500 TPA	Nil	Nil

Table 2.3.2 (Contd...): Raw Material Input Requirements with Fuel Characteristics in Major Industries

Sr. No.	Industry	Raw Materials & Quantity	No. of Boilers & Capacity	Fuel Used in each Boiler	No. of Furnace, Type & Quantity	Total Quantity of Fuel used	Fuel Characteristics
42.	Hira Steels Ltd.	Billet (254 TPD)	Nil	Nil	(1), Re-heating Induction furnace	5712 l/day of Furnace Oil and Producer Gas	PG- N_2: 55%, CO_2: 4-5%, H_2: 10-11%, GCV: 950Kcal/m^3, FO- H_2: 11%, S:3.5%, C: 84%, GCV: 10200 Kcal/kg
43.	Alankar Steels Ltd.	Re-Rollable Sponge Material & Pig Iron (21.45 KTPD), Meltings (30 KTPD)	Nil	Nil	Re-heating Induction Furnace (2x7 TPH),	4 l/T oil	Nil
44.	Hira Power & Steels Ltd.	Mn Ore (285 TPD), Coal (49 TPD), Dolomite (25 TPD), Ferro Slag (10 TPD)	Nil	Nil	Nil	4000-4200 units of electricity	Ash: 24-32%, VM: 26-30%, FC: 48-52%, Moisture: 10-15%

Table 2.3.3: Stack and Flue Gas Characteristics of Sponge Iron, Power and Ferro Alloy Plants in Raipur Region

Sr. No.	Industry	Stack Attached to Unit & Capacity	Material of Construct-ion	Stack Height, (m)	Stack Diameter, (m)	Flue Gas Temp. (°C)	Flue Gas Velocity, (m/s)	Volumetric Flow rate* (Nm^3/hr)	Control Equipment with Efficiency
	Siltara Industrial Area								
1.	Sarda Energy and Minerals Ltd.	SIP1 (2x500 TPD)	RCC	65	3.9	140	10.0	313336	WHRB & ESP (99%)
		SIP2 (2x100 TPD)	RCC	42	3.9	140	9.0	279132	WHRB & ESP (99%)
		PP (61.5 MW) + 1 standby stack	RCC	90	3.3	140	9.1	202295	ESP (99%)
		FA1	MS	40	1.2	110	13.8	43695	FD coolers with bag filters
		FA2	MS	40	1.8	100	7.6	55595	
2.	Godawari Power & Ispat	AFBC (53 MW) + SIP1 (350 TPD)	MS	70	2.2	140	9.0	88823	WHRB & ESP (99%)
		SIP2 (500 TPD)	RCC	70	2.4	140	9.0	105707	WHRB &ESP (99%)
		SIP 3 & 4 (2x500 TPD)	RCC	70	2.4	140	9.0	105707	WHRB &ESP (99%)
3.	Vandana Global Pvt. Ltd.	SIP (700 TPD)	RCC	70	4.9	160	3.3	152846	WHRB & ESP (95%)
		PP (38 MW)	RCC	92	3.2	130	8.0	170120	ESP (95%)
		FA (54.5 TPD)	MS	45	2.7	105	13.0	211139	Bag Filter (90%)
4.	S.K.S Ispat Pvt. Ltd.	SIP1 (2x100 TPD)	RCC	45	3.0	120	10.0	192858	WHRB & ESP (99.9%)
		SIP2 (2x350 TPD)	RCC	60	3.5	12[illegible]	10.0	262502	WHRB & ESP (99.9%)
		PP (30 MW)	RCC	80	2.5	15[illegible]	20.0	248862	ESP (99.9%)
		FA (90 TPD)	MS	45	0.6	60[illegible]	8.0	2783	Bag Filter
		RM (2x500 + 1x 200 TPD) -3 Stacks	MS	50	2.0	30[illegible]	8.0	47031	Reciprocator
5.	Droliya Electrosteels Pvt. Ltd.	SIP (2x100 TPD)	MS	42	1.1	160	14.0	32947	ESP (99%)
		IF (2x100 TPD)	MS	21	0.6	50	1.0	939	Suction Hood
6.	Mahendra Sponge Iron and Power Pvt. Ltd,	SIP (2x100 TPD)	MS	40	1.3	12[illegible]	9.0	32593	ESP, Bag Filter (99%)
		PP (8 MW)	RCC	51	1.4	12[illegible]	9.0	37800	ESP, Bag Filter (99%)
7.	N.R Sponge Pvt. Ltd.	SIP (2x100 TPD)	MS	45	2.0	20[illegible]	7.0	49852	ESP, Bag Filter
8.	Sree Nakoda Ispat Ltd.	SIP (200 TPD) + PP (11 MW)	RCC	60	3.6	15[illegible]	5.0	131169	Bag Filter (99.8%)

Table 2.3.3 (Contd...): Stack and Flue Gas Characteristics of Sponge Iron, Power and Ferro Alloy Plants in Raipur Region

Sr. No.	Industry	Stack Attached to	Material of Construct-ion	Stack Height, (m)	Stack Diameter, (m)	Flue Gas Temp. (°C)	Flue Gas Velocity, (m/s)	Volumetric Flow rate* (Nm3/hr)	Control Equipment with Efficiency
9.	Baldev Alloys Pvt. Ltd.	SIP1-DRI (2x50 TPD)	MS	42	1.2	145	7.0	20308	ESP
		SIP2-DRI (1x50 TPD)	MS	42	1.2	145	7.0	20308	ESP
10.	S.K. Sarawagi & Co. Pvt. Ltd	SIP-DRI (2x100 TPD)	RCC	55	2.5	175	18.0	211477	ESP (99%)
		RM (150 TPD)	MS	32	0.6	95	9.5	7826	Suction Hood
		IF (160 TPD)	MS	30	0.4	95	5.1	1875	Suction Hood
11.	Rashmi Sponge Iron Pvt. Ltd.	SIP-DRI (2x100 TPD)	MS	55	3.6	165	18.0	461076	ESP (99.75%)
		PP (8 MW)	RCC	48	1.0	140	6.0	12235	ESP (99.75%)
		IF (300 TPD)	MS	30	0.5	90	5.1	2958	Cyclone Separator
12.	Aarti Sponge & Power Ltd.	SIP-Kiln (2x100 TPD)	RCC	62	2.5	105	6.0	83546	ESP (80%)
13.	Shree P.D. Industries	SIP-DRI (200 TPD)	MS	44	3.0	145	3.1	56951	ESP (99.75%)
14.	Agrawal Sponge Ltd.	SIP-3xKilns (100+50+50 TPD) – common stack	MS	42	1.2	180	10.0	26770	ESP, Bag Filter
15.	G.R Sponge and Power Ltd.	SIP (2x100 TPD)	MS	45	1.8	100	3.5	25603	WHRB & ESP (99%)
		AFBC (4 MW)	MS	48	1.4	100	7.0	30977	ESP (99%)
16.	Ghankun Steels Pvt. Ltd.	SIP1-Kiln (150 TPD)	MS	48	1.25	190	7.0	19894	ESP (< 50%)
		SIP2 (2x50 TPD)	MS	45	1.0	190	5.0	9094	ESP (< 50%)
17.	Devi Iron & Power Pvt. Ltd	SIP-DRI (150 TPD)	MS	42	1.8	120	4.8	33326	ESP
18.	Abhijeet Infrastructure	SIP-DRI (350 TPD)	RCC	70	4.16	169	7.0	230808	ESP (99.5), Bag Filter
		PP (7.5 MW)	RCC	60	3.0	142	7.0	127844	ESP (99.5%)
19.	Vaswani Industries Ltd.	SIP (2x100 TPD)	MS	45	1.5	170	9.0	38495	ESP (90%)
		PP (3 MW)	MS	48	1.3	180	9.0	28276	ESP (95%)
20.	Euro Pratik Ispat Pvt. Ltd.	SIP (100 TPD)	MS	42	1.2	200	9.0	23074	ESP & Bag Filter
21.	Bhagwati Power & Steel Ltd	SIP (2x100 TPD) Kiln	RCC	45	1.5	180	6.0	25097	ESP & Bag Filter (99%)

Table 2.3.3 (Contd...): Stack and Flue Gas Characteristics of Sponge Iron, Power and Ferro Alloy Plants in Raipur Region

Sr. No.	Industry	Stack Attached to	Material of Construct-ion	Stack Height, (m)	Stack Diameter, (m)	Flue Gas Temp. (°C)	Flue Gas Velocity, (m/s)	Volumetric Flow rate* (Nm3/hr)	Control Equipment with Efficiency
22.	API Ispat & Powertech Ltd.	SIP-Kiln (350 TPD) + 8 MW - WHRB	RCC	60	4	160	10.0	311186	ESP-3
		PP-AFBC (7 MW)	RCC	78	2.7	160	10.0	141784	ESP
23.	Trimula Sponge Iron Pvt. Ltd.	SIP (100 TPD)	MS	45	1.5	<100	6.0	30480	ESP (96%)
24.	Corporate Ispat and Alloys Ltd.	SIP-Kiln (500 TPD) + WHRB (52 TPH)	RCC	80	4.16	150	7.0	241175	ESP, Bag Filter (99.5%)
25.	Maa Usha Urja Ltd.	PP (7.5 MW)	MS	50	1.2	160	6.3	17644	ESP (99.5%)
26.	Sunil Sponge Pvt. Ltd.	SIP-DRI (200 TPD)	MS	40	2.5	180	8.0	92952	ESP (80%)
27.	Jagdamba Power & Alloys Ltd.	PP (25 MW)	RCC	75	3.5	140	2.8	69941	ESP (99.9%)
28.	Jayaswal Neco Ind. Ltd.	PP (14 MW)	MS	70	3.5	128	6.4	164649	ESP (99.5%)
		Sinter	MS	55	1.5	133	6.1	28469	ESP, Bag Filter (99.5%)
	Borjhara-Urla Industrial Area								
29.	Satyarth Steel & Power Pvt. Ltd.	SIP1 (50 TPD)	MS	30	1.2	90	14.0	46771	Venturi-cyclone (90%)
		SIP2 (50 TPD)	MS	30	1.2	90	14.0	46771	Venturi-cyclone (90%)
30.	Shree Sita Ispat & Power Pvt. Ltd	SIP (100 TPD)	MS	40	1.0	90	5.0	11600	ESP (98%)
31.	Real Ispat and Power Pvt. Ltd.	SIP (200 TPD) +PP (12 MW)	RCC	62	2.0	150	11.0	95563	ESP (99.99%)
32.	Shilpy Steels Pvt. Ltd.	SIP1 (50 TPD)	MS	33	0.8	90	10.0	14848	Venturi-Scrubber (89%
		SIP2 (50 TPD)	MS	33	0.8	90	10.0	14848	Venturi-Scrubber (89%)
33.	Raghuveer Ferro Alloys	BF	MS	20	1.4	275	7.0	20338	Bag Filter

*calculated at 25 °C

Table 2.3.3 (Contd...): **Stack and Flue Gas Characteristics of Sponge Iron, Power and Ferro Alloy Plants in Raipur Region**

Sr. No.	Industry	Stack Attached to	Material of Construct-ion	Stack Height, (m)	Stack Diameter, (m)	Flue Gas Temp. (°C)	Flue Gas Velocity, (m/s)	Volumetric Flow rate* (Nm3/hr)	Control Equipment with Efficiency
34.	Srinivasa Ferro Alloys	FA - 4 Stacks	MS	30	1.8	80	4.0	30919	Bag Filter
35.	Sri Girija Smelters Ltd.	FA - 4 Stacks	MS	30	1.8	80	4.0	30919	Bag Filter
36.	Hira Ferro Alloys Ltd. Unit I & II	PP (20 MW)	RCC	73	2.5	110	5.0	68713	ESP (99.9%)
		FA1 (20 TPD)	MS	35	1.5	55	5.0	28885	Bag Filter (99.9%)
		FA 2 (60TPD) Stack1	MS	35	1.2	50	5.0	18772	Bag Filter (99.9%)
		Stack 2	MS	35	1.6	50	4.0	26698	Bag Filter (99.9%)
37.	Indsil Energy and Electro-chemicals Ltd.	PP-AFBC (11 MW)	MS	63	2.1	132	12.1	110958	ESP (99.9%)
38.	Deepak Ferro Alloys	FA (120 TPD)	MS	30	1.8	90	12.0	90200	Venturi-Scrubber (90%)
39.	Alok Ferro Alloys Ltd.	PP (8 MW)	RCC	73	2.5	140	9.0	114699	ESP (99.8%)
		FA (30 TPD) – 2 Stacks	MS	34	1.5	45	7.0	41710	Bag Filter (99%)
40.	Monnet Ispat & Energy Pvt. Ltd	SIP-1 (50 TPD)	MS	33	1.2	80	6-8	24048	Bag Filter (99%)
		SIP-2 (50 TPD)	MS	33	1.2	80	6-8	24048	Bag Filter (99%)
							6-8	15365	Reciprocator (98%)
41.	R.R. Ispat Ltd.	Re-Rolling Mill	MS	32	1.0	<150	6-8	67451	N.A
42.	Hira Steels Ltd.	Re-Rolling Mill	MS	31	2.2	<150	6-8	55745	Water Scrubber
43.	Alankar Steels Ltd.	Rolling Mill	MS	30	2.0	<150	7.0	55745	Bag Filter (85%)
		Furnace	MS	30	2.0	<150	7.0	286689	ESP (96.7%)
44.	Hira Power & Steels Ltd.	Power Plant	RCC	73	4.0	<150	8-10	55745	Bag Filter (98%)
		Smelting	MS	30	2.0	<150	7.0		

*calculated at 25 °C

Table 2.3.4: Sources of Fugitive Emissions Generation in Industries of Raipur Region

Sr. No.	Industry	Unloading of Materials	Ash Disposal	Brick Making	Disposal of Solid Waste	Collection of Solid Waste (below ESP, BF)	Truck movement	Loose Soil Blown by Wind	Solid Fuel Handling	Efforts for Controlling Air/ Water/Solid Pollution
	Siltara Industrial Area									
1.	Sarda Energy and Minerals Ltd.	Yes	Yes	No	No	Yes	Yes	Yes	No	ESP/ ST, Soak-pits, Water spraying, road construction
2.	Godawari Power & Ispat	No	Yes	No	Yes	Yes	No	No	No	ESP/ Water sprinkling / Magnetic separators
3.	Vandana Global Pvt. Ltd.	Yes	No	No	No	No	Yes	Yes	Yes	ESP / Water recycling / Used as filler material
4.	S.K.S. Ispat Pvt. Ltd.	Yes	Yes	No	Yes	No	Yes	No	Yes	BF / Water sprinkling.
5.	Droliya Electrosteels Pvt. Ltd.	Yes	Yes	No	Yes	Yes	Yes	Yes	No	BF / Water sprinkling
6.	Mahendra Sponge Iron and Power Pvt. Ltd,	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Land leased for SW disposal
7.	N.R. Sponge Pvt. Ltd.	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	ESP, Bag filter, Water sprinkling
8.	Sree Nakoda Ispat Ltd.	Yes	Yes	Yes	No	No	Yes	No	No	ESP, BF, De-Dusting System/ Brick Making
9.	Baldev Alloys Pvt. Ltd.	Yes	Nil	Proposed	Yes	No	Yes	No	Yes	ESP
10.	S.K. Sarawagi & Co. Pvt. Ltd.	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Solid waste disposed to quarries/land fill
11.	Rashmi Sponge Iron Pvt. Ltd.	Yes	Yes	No	Yes	No	Yes	Yes	Yes	ESP, Bag filter
12.	Aarti Sponge & Power Ltd.	Yes	Yes	No	Yes	No	Yes	Yes	Yes	ESP
13.	Shree P.D. Industries	Yes	Yes	No	No	Yes	No	Yes	Yes	ESP, Bag filter
14.	Agrawal Sponge Ltd.	Yes	Yes	No	Yes	Yes	Yes	No	No	ESP, Scrubber

Table 2.3.4 (Contd...): Sources of Fugitive Emissions Generation in Industries of Raipur Region

Sr. No.	Industry	Unloading of Materials	Ash Disposal	Brick Making	Disposal of Solid Waste	Collection of Solid Waste (below ESP, BF)	Truck move-ment	Loose Soil Blown by Wind	Solid Fuel Handling	Efforts for Controlling Air/ Water/Solid Pollution
15.	G.R. Sponge and Power Ltd.	No	Yes	No	No	Yes	Yes	No	No	Water sprinkling, Dust cleaning of entire paved area
16.	Ghankun Steels Pvt. Ltd.	Yes	No	No	No	No	Yes	No	No	ESP, Scrubber
17.	Devi Iron & Power Pvt. Ltd	Yes	Yes	Yes	No	Yes	Yes	Yes	No	ESP, Bag Filter, Water Spray
18.	Abhijeet Infrastructure	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	ESP
19.	Vaswani Industries Ltd.	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	ESP, Dust settling chamber
20.	Euro Pratik Ispat Pvt. Ltd.	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Water sprinkling
21.	Bhagwati Power & Steel Ltd	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	ESP, BF / Water sprinkling
22.	API Ispat & Powertech Ltd.	No	No	No	No	No	No	No	No	ESP/Zero discharge/ Covered transport of materials, Water Sprinkling
23.	Trimula Sponge Iron Pvt. Ltd.	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	ESP, Water Spray
24.	Corporate Ispat and Alloys Ltd.	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	ESP, Bag Filter, Dust separator
25.	Maa Usha Urja Ltd.	No	No	No	No	No	No	No	No	N.A
26.	Sunil Sponge Pvt. Ltd.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	ESP
27.	Jagdamba Power & Alloys Ltd.	Yes	Yes	Yes	No	No	Yes	No	No	ESP
28	Jayaswal Neco Ind. Ltd.	No	No	No	No	No	No	No	No	SW Fully used in Sinter Plant / Water recycling

Table 2.3.4 (Contd...): Sources of Fugitive Emissions Generation in Industries of Raipur Region

Sr. No.	Industry	Unloading of Materials	Ash Disposal	Brick Making	Disposal of Solid Waste	Collection of Solid Waste (below ESP, BF)	Truck move-ment	Loose Soil Blown by Wind	Solid Fuel Handling	Efforts for Controlling Air/ Water/Solid Pollution
	Urla Industrial Area									
29.	Satyarth Steel & Power Pvt. Ltd.	Yes	Yes	No	Yes	Yes	Yes	No	Yes	ESP
30.	Shree Sita Ispat & Power Pvt. Ltd	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	ESP, BF/Water sprinkling
31.	Real Ispat and Power Pvt. Ltd.	Yes	No	No	No	No	No	No	No	Water sprinkling/ Covered storage, Garland drain
32.	Shilpy Steels Pvt. Ltd.	Yes	Yes	No	No	No	No	No	No	BF/Water sprinkling
33.	Raghuveer Ferro Alloys	x	No	No	No	No	Yes	Yes	Yes	BF/Water sprinkling
34.	Srinivasa Ferro Alloys	Yes	No	No	No	No	Yes	No	Yes	Bag filter
35.	Sri Girija Smelters Ltd.	Yes	No	No	No	No	Yes	No	Yes	Bag filter
36.	Hira Ferro Alloys Ltd.	Yes	No	No	No	No	No	No	No	ESP, BF, Brick making
37.	Indsil Energy and Electrochemicals Ltd.	Yes	Yes	No	No	Yes	No	No	Yes	DSS, Automatic Water sprinkling in M.S.Silicos
38.	Deepak Ferro Alloys	Yes	No	No	No	No	Yes	No	No	Venturi Scrubber
39.	Alok Ferro Alloys Ltd.	Yes	Yes	No	No	No	No	No	No	Road Construction
40.	Monnet Ispat & Energy Pvt. Ltd	No	No	No	No	No	No	No	No	ESP, Water sprinkling/ Land filling
41.	R.R. Ispat Ltd.	No	No	No	No	No	Yes	Yes	No	Water sprinking
42.	Hira Steels Ltd.	No	No	No	No	No	x	x	x	Road construction
43.	Alankar Steels Ltd.	No	No	No	No	Yes	No	No	No	Water scrubber / Rain water harvesting
44.	Hira Power & Steels Ltd.	Yes	No	No	Yes	Yes	Yes	No	No	Bag filter

Table 2.3.5: Status of Inside and Outside Roads along with the Movement of Heavy Duty Vehicles in the Industries

Sr. No.	Industry	Road Distance from Jai Stambh Chowk, (km)	Entrance Road from Main Road		Motor able Road inside the Factory		Movement of Trucks/other Vehicles within Factory Area	
			Type	Length, (km)	Type	Length, (km)	Nos.	Distance, (km)
	Siltara Industrial Area							
1	Sarda Energy and Minerals Ltd.	16	Tarred	0.9	Concrete	3.5	200-500	28
2.	Godawari Power & Ispat	20	Tarred	1.5	Concrete	4	100	x
3.	VandaN.A Global Pvt. Ltd.	16	Concrete	0.5	Concrete	3	50-70	3
4.	S.K.S. Ispat Pvt. Ltd.	15	Concrete		Concrete	10	200	2
5.	Droliya Electrosteels Pvt. Ltd.	North, <23	Concrete	1.25	Concrete	2	30-40	2-3
6.	Mahendra Sponge Iron and Power Pvt. Ltd,	13	Concrete	2	Concrete Unpaved	1.5 + 1	5	50
7.	N.R. Sponge Pvt. Ltd.	x	x	x	x	x	x	x
8.	Sree N.Akoda Ispat Ltd.	18	Concrete	3	Concrete	3	30-40	1.5
9.	Baldev Alloys Pvt. Ltd.	x	x	x	x	x	x	x
10.	S.K. Sarawagi & Co. Pvt. Ltd.	25	Concrete	x	Concrete	x	10	2
11.	Rashmi Sponge Iron Pvt. Ltd.	x	x	x	x	x	x	x
12.	Aarti Sponge & Power Ltd.	20	Concrete	3	Concrete	1.5	4	N.A
13.	Shree P.D. Industries	x	x	x	x	x	x	x
14.	Agrawal Sponge Ltd.	16	Concrete	x	Concrete	x	3-4	0.5
15.	G.R. Sponge and Power Ltd.	30	Concrete	2		1	15	2
16.	Ghankun Steels Pvt. Ltd.	17	Concrete	4.5	Concrete	1.5	15-20	2-3
17.	Devi Iron & Power Pvt. Ltd	x	x	x	x	x	x	x
18.	Abhijeet Infrastructure	North , <20	WMB	x	x	0.3	15	0.3
19.	Vaswani Industries Ltd.	x	x	x	x	x	x	x
20.	Euro Pratik Ispat Pvt. Ltd.	25	Tarred	x	Concrete	x	25	3
21.	Bhagwati Power & Steel Ltd	20	Concrete	x	x	x	x	x
22.	API Ispat & Powertech Ltd.	22	Tarred	2	Concrete	0.92	60	62
23.	Trimula Sponge Iron Pvt. Ltd.	x	x	x	x	x	x	x
24.	Corporate Ispat and Alloys Ltd.	20	Concrete	1	x	0.3	15	0.1
25	Maa Usha Urja Ltd.	18	WBM	1	x	0.2	2-3	0.2
26.	Sunil Sponge Pvt. Ltd.	x	x	x	x	x	x	x
27.	Jagdamba Power & Alloys Ltd.	19	Unpaved	1	Unpaved	2	35	2
28.	Jayaswal Neco Ind. Ltd.	>20	Tarred	.5		5	20	3

Table 2.3.5 (Contd...) : Status of Inside and Outside Roads along with the Movement of Heavy Duty Vehicles in the Industries

Sr. No.	Industry	Distance from Jai Stambh Chowk, (km)	Entrance Road from Main Road		Motor able Road inside the Factory		Movement of Trucks/other Vehicles within Factory Area	
			Type	Length, (km)	Type	Length, (km)	Nos.	Distance, (km)
	Urla Industrial Area							
29.	Satyarth Steel & Power Pvt. Ltd.	15	Unpaved	2	Unpaved	1	10	1
30.	Shree Sita Ispat & Power Pvt. Ltd	x	Tarred	x	N.A	x	10	20
31.	Real Ispat and Power Pvt. Ltd.	16	WBM	0.5	Concrete	2	50	0.4
32.	Shilpy Steels Pvt. Ltd.	15	Concrete	1	Concrete	x	10	2
33.	Raghuveer Ferro Alloys	x	x	x	x	x	x	x
34.	Srinivasa Ferro Alloys	13	x	x	x	x	10-15	0.5
35.	Sri Girija Smelters Ltd.	13	x	x	x	x	10-15	0.5
36.	Hira Ferro Alloys Ltd.	13	Tarred	3	Concrete	4	40	3
37.	Indsil Energy and Electro-chemicals Ltd.	15	Concrete	x	x	x	10-12	0.4
38.	Deepak Ferro Alloys	10	Concrete	x	x	x	10	0.2
39.	Alok Ferro Alloys Ltd.	11	Concrete	x	Concrete	x	10	2
40.	Monnet Ispat & Energy Pvt. Ltd	15	Concrete	2.4	Concrete	3.3	200	3.3
41.	R.R. Ispat Ltd.	x	x	x	x	x	x	x
42.	Hira Steels Ltd.	x	x	x	x	x	x	x
43.	Alankar Steels Ltd.	10	Concrete	x	Concrete	x	10	2
44.	Hira Power & Steels Ltd.	x	x	x	x	x	x	x

x – Data/information not available

Table 2.3.6: Environmental Management Practices Adopted by Industries in Raipur Region

Sr. No.	Industry	Factory Area, (ha)	Green belt Area, (ha)	No. of Trees Planted	Type & Quantity of Solid Waste Generated, (TPD)	Quantity of Reusable Solid Waste, (TPD)	Treatment & Disposal of Solid Waste	Quantity of Wastewater Generated, (KL/d)	Wastewater Treatment & Disposal Facility
	Siltara Industrial Area								
1.	Sarda Energy and Minerals Ltd.	--	5.73	17,541	Char & Dolochar- 255, Dust -14, Fly Ash- 271, Slag- 195	100%	in FBC Boiler	N.A	Neutralisation Pit, Soak Pit, Settling Tank
2.	Godawari Power & Ispat	--	--	83,349	Char & Dolochar - 500, Fly Ash- 385	--	--	Power Plant Waste Water, 120	Nil
3.	Vandana Global Pvt. Ltd.	23.01	3.23	10,000	Char & Dolochar- 161.7, Fly Ash- 289.5, Slag- 7.5	Char & Dolochar- 80.7, Fly Ash - 6.68	Cement Plant, Brick Making, Filling in low lying area (LLA)	80	Nil
4.	S.K.S. Ispat Pvt. Ltd.	121.40	12.1	70,000	Char & Dolochar- 200	--	Used in AFBC Boiler	25	Septic Tank, neutralisation Pit, settling tank
5.	Droliya Electro-steels Pvt. Ltd.	7.7	5	15,971	Dolochar, Dust & Slag. Total (70)	100% usage	Dolochar as Fuel. Dust as land filling	Nil	Nil
6.	Mahendra Sponge Iron and Power Pvt. Ltd,	12.94	1.21	3,000	Char- 35 Dolochar– 35, Fly Ash- 60	Dolochar-35	Char sold to brick makers and fly ash to cement plant	30	Watering plant and other guarding work
7.	N.R. Sponge Pvt. Ltd.	7.0	Along peri-pheri	2000	Dolochar – 12 TPD ESP Dust – 30 TPD	Nil	Land filling and sold for bricks	2	Soak Pit
8.	Sree Nakoda Ispat Ltd.	8.85	--	10,000 Bushy Plants	Fly ash - 6.53	Nil	Sold to cement manufacturers	2	Reused for plantation & brick Making
9.	Baldev Alloys Pvt. Ltd.	--	--	--	--	--	--	--	--
10.	S.K. Sarawagi & Co. Pvt. Ltd.	8.08	2.02	15,000	80	--	Dumped in Dead Mines	Nil	Nil

Table 2.3.6 (Contd...): Environmental Management Practices Adopted by Industries in Raipur Region

Sr. No.	Industry	Factory Area, (ha)	Green belt Area, (ha)	No. of Trees Planted	Type & Quantity of Solid Waste Generated, (TPD)	Quantity of Reusable Solid Waste, (TPD)	Treatment & Disposal of Solid Waste	Quantity of Wastewater Generated, (KL/d)	Wastewater Treatment & Disposal Facility
11.	Rashmi Sponge Iron Pvt. Ltd.	--	--	--	Char/ dolochar – 19.8K TPA Slag – 10K TPA Flyash -	Char/ dolochar – 14K TPA Slag – 2.1 K TPA	Char as fuel in power plant. Slag in low lying area & road construction Flyash – free for brick making	Domestic – 2 Industrial - 15	
12.	Aarti Sponge & Power Ltd.	--	--	4,000	Fly Ash, Dust, Dolochar	--	--	20	Water Softner Plant
13.	Shree P.D. Industries	9.7	--	--	Dolochar Fly Ash	100% dolochar for power	Nil	21	Neutralization
14.	Agrawal Sponge Ltd.	3.23	0.404	400	Dolochar, Slag- (20)	Nil	Nil	--	--
15.	G.R. Sponge and Power Ltd.	4.7	1.096	3,000	Char/Dolochar - 65 Fly ash - 55 Ash - 45	Dolochar- 20 TPD	Dolochar-partly as fuel, rest sold for filling in LLA. Fly ash-sold for cement & brick manufacture	Blow down Water 15	Neutralisation
16.	Ghankun Steels Pvt. Ltd.	11.71	1.01	3,000	100	Nil	Sold to Brick Manuf. & Power Plants	Nil	Nil
17.	Devi Iron & Power Pvt. Ltd	10.9	--	--	Char/Dolochar – 90	Proposed	Brick manfacture	10	Nil
18.	Abhijeet Infrastructure	11.8	3.5	6,780	Fly Ash- 100, Dust- 70, Dolochar - 80	100 % Dolochar usage	Filling LLA, sinter plant, brick plant	50	Neutralization, sprinkling to suppress dust and fly ash

Table 2.3.6 (Contd...): Environmental Management Practices Adopted by Industries in Raipur Region

Sr. No.	Industry	Factory Area, (ha)	Green belt Area, (ha)	No. of Trees Planted	Type & Quantity of Solid Waste Generated, (TPD)	Quantity of Reusable Solid Waste, (TPD)	Treatment & Disposal of Solid Waste	Type & Quantity of Wastewater Generated, (KL/d)	Wastewater Treatment & Disposal Facility
19.	Vaswani Industries Ltd.	11.8	--	--	Char/Dolochar - 16.43 ESP dust - 34.5 Slag – 100 kg/t	20-30% flyash for brick	Dolochar sold to brick manufacturers, dust & slag filling low lying areas	35	Septic tank Settling tank & reuse for cooling
20.	Euro Pratik Ispat Pvt. Ltd.	--	30%	2,000	45	--	--	Nil	Nil
21.	Bhagwati Power & Steel Ltd	--		2,000	Char	--	--	--	--
22.	API Ispat & Powertech Ltd.	39.21	102.74	15,400	Char & Dolochar-96, Dust- 14, Fly Ash- 116, Slag-16, Mill Scale- 1	100 % usage	As fuel, As Filling Material in LLA, Brick Making, Sold to Ferro Alloy Plants	Blow Down water- 432, Softner- 216, Domestic- 8	Neutralization, sprinkling to suppress dust and fly ash
23.	Trimula Sponge Iron Pvt. Ltd.	14.2	1.2	12,000	Dolochar – 35 ESP dust – 10	Nil	Nil	Industry - 10 Domestic - 2	Nil
24.	Corporate Ispat and Alloys Ltd.	23.3	7.2	7,320	Dolochar- 110 Dust-90	Nil	Dolochar as Fuel, Dust as Filling Material in LLA	Nil	Nil
25	Maa Usha Urja Ltd.	8.97	2.7	4,310	Fly Ash- 80	Nil	Cement Plant	Nil	Nil
26.	Sunil Sponge Pvt. Ltd.	5.26	1.8	14,000	Dolochar – 70 ESP dust – 10 Slag – 8	Nil	Dust as Filling Material in LLA	140	Cooling tower Plantation
27.	Jagdamba Power & Alloys Ltd.	20.55	2	27,773	Nil	Nil	Cement Plant, Brick Making, Filling LLA	50	Neutralisation, used in Ash Conditioning, Plantation

Table 2.3.6 (Contd...): Environmental Management Practices Adopted by Industries in Raipur Region

Sr. No.	Industry	Factory Area, (ha)	Green belt Area, (ha)	No. of Trees Planted	Type & Quantity of Solid Waste Generated, (TPD)	Quantity of Reusable Solid Waste, (TPD)	Treatment & Disposal of Solid Waste	Type & Quantity of Wastewater Generated, (KL/d)	Wastewater Treatment & Disposal Facility
28.	Jayaswal Neco Ind. Ltd.	404	120	4,41,128	ESP dust	100% usage	Brick making	Nil	Nil
29.	Satyarth Steel & Power Pvt. Ltd.	30	18	5,000	Dolochar- 40	Nil	Filling LLA	5	--
30.	Shree Sita Ispat & Power Pvt. Ltd	8.1	--	5,000	20	--	Sold for brick making	5	Plantation Suppress dust
31.	Real Ispat and Power Pvt. Ltd.	61	8	18,000	Dolochar - 80 Fly ash - 110	100 % Usage	Dolochar as fuel, Fly ash in cement and Brick Making	Domestic- 12, Cooling Blow down- 30, DM plant 5, Boiler Blow down - 5	Domestic- septic tank and soak pit. Others- settling tank
32.	Shilpy Steels Pvt. Ltd.	6.1	2.424	6,000	60	--	--	--	--
33.	Raghuveer Ferro Alloys	x	4 sides	160	Slag – 4K TPA	Nil	Nil	Nil	Nil
34.	Srinivasa Ferro Alloys	4.45	--	--	--	--	--	--	--
35.	Sri Girija Smelters Ltd.	2.43	--	200	--	--	--	--	--
36.	Hira Ferro Alloys Ltd.	15	2.25	5,000	--	--	--	--	--
37.	Indsil Energy and Electrochemicals Ltd.	--	--	4,00,232 plants	Fly Ash- 120	--	Supplied to Cement Plant, Brick Making	3	Soak Pit
38.	Deepak Ferro Alloys	1.8	1.82	200	Slag- 30	Nil	Filling LLA	Nil	Nil
39.	Alok Ferro Alloys Ltd.	x	0.404	5,000	Slag- 50	100%	Filling LLA	Nil	Nil

Table 2.3.6 (Contd...): Environmental Management Practices Adopted by Industries in Raipur Region

Sr. No.	Industry	Factory Area, (ha)	Green belt Area, (ha)	No. of Trees Planted	Type & Quantity of Solid Waste Generated, (TPD)	Quantity of Reusable Solid Waste, (TPD)	Treatment & Disposal of Solid Waste	Type & Quantity of Wastewater Generated, (KL/d)	Wastewater Treatment & Disposal Facility
40.	Monnet Ispat & Energy Pvt. Ltd	81.6	27	54,575	Ash– 900 Char- 250 Slag- 100	--	Char as fuel, ash sold to brick makers, slag used as filling material	800	Settling Tanks used for Dust Suppression and Plantation
41.	R.R. Ispat Ltd.	--	--	--	Nil	Nil	Nil	13	Used for plantation
42.	Hira Steels Ltd.	9.03	--	--	Mill scale - 1	Nil	Filling LLA	Nil	Nil
43.	Alankar Steels Ltd.	--	--	1,500 plants	Nil	Nil	Nil	Nil	Nil
44.	Hira Power & Steels Ltd.	3.84	17,438 sq.m		Silico-Mn Slag - 25	Nil	Road construction &filling LLA	Nil	Nil

--: data/information not available/applicable, LLA- Low Lying Area

Chapter 3

Air Quality Status of Raipur Region

Chapter 3

Air Quality Status of Raipur Region

3.1 Introduction

Air quality management primarily calls for establishing the interrelationship among the ambient air quality, emission inventory and meteorology of the study area. Establishing ambient air quality status demands air quality monitoring of various pollution parameters, as identified critical for the region. However, a universally accepted practice is to measure criteria pollutants to examine the influence of anthropogenic sources. Besides criteria pollutants (SPM, RSPM etc.), chemical species (ions & heavy metals) are also monitored to identify different types of sources, chemical transformation in the atmosphere leading to secondary pollutants formation etc.

Keeping in view the objectives of the study, major criteria pollutants, viz. SPM, RSPM (PM_{10}), SO_2 and NO_2 were primarily focused with chemical speciation of RSPM samples for Cations, Anions and Heavy metal contents. In addition, monitoring for other gaseous pollutants like CO, HC and volatile organic compounds (VOCs) was also carried out for limited period to get the preliminary information about their existing concentration levels in Raipur region. Criteria pollutants with recommended sampling and analysis protocol were monitored at 8 locations over a period of 8 days continuously. The air quality data thus generated has been analyzed to define the air quality status of the region. The air quality parameters are compared with the applicable regulatory standards. The data has been analyzed in the following manner:

- Statistical summary of 24 hourly average concentration levels of criteria pollutants at all the sites with respect to minimum, maximum, average and standard deviation values
- Monitoring site-wise 8 hourly variations in ambient air quality parameters
- Status of specific gaseous pollutants (CO, HC, VOCs)
- Chemical characteristics of RSPM samples with respect to Cations (Na^+, K^+, Ca^{2+}, Mg^{2+} & NH_4^+), Anions (SO_4^{2-}, NO_3^-, Cl^- & F^-) and Heavy metals (Fe, Cu, Cr, Cd, Co, Zn, Ni, Pb & Mn).

Prior to analysis of air quality data, first, the air quality monitoring methodology including details of the sampling locations, parameters monitored, frequency of sampling etc. are described here.

3.2 Air Quality Monitoring Methodology

3.2.1 Sampling Sites Description

In order to assess the impact of industrial emissions along with other sources of air pollution, ambient air quality monitoring was conducted in residential areas/mixed activity zones of Raipur city and in the nearby rural areas/villages. In all, 4 sites within Raipur city and 3 sites in rural areas were selected with a reference rural site located mainly in the upward direction of the Siltara industrial area. The locations of ambient air quality monitoring stations are shown in **Plate 3.2.1**. Characteristics of each air quality monitoring sites are summarized briefly in **Table 3.2.1**.

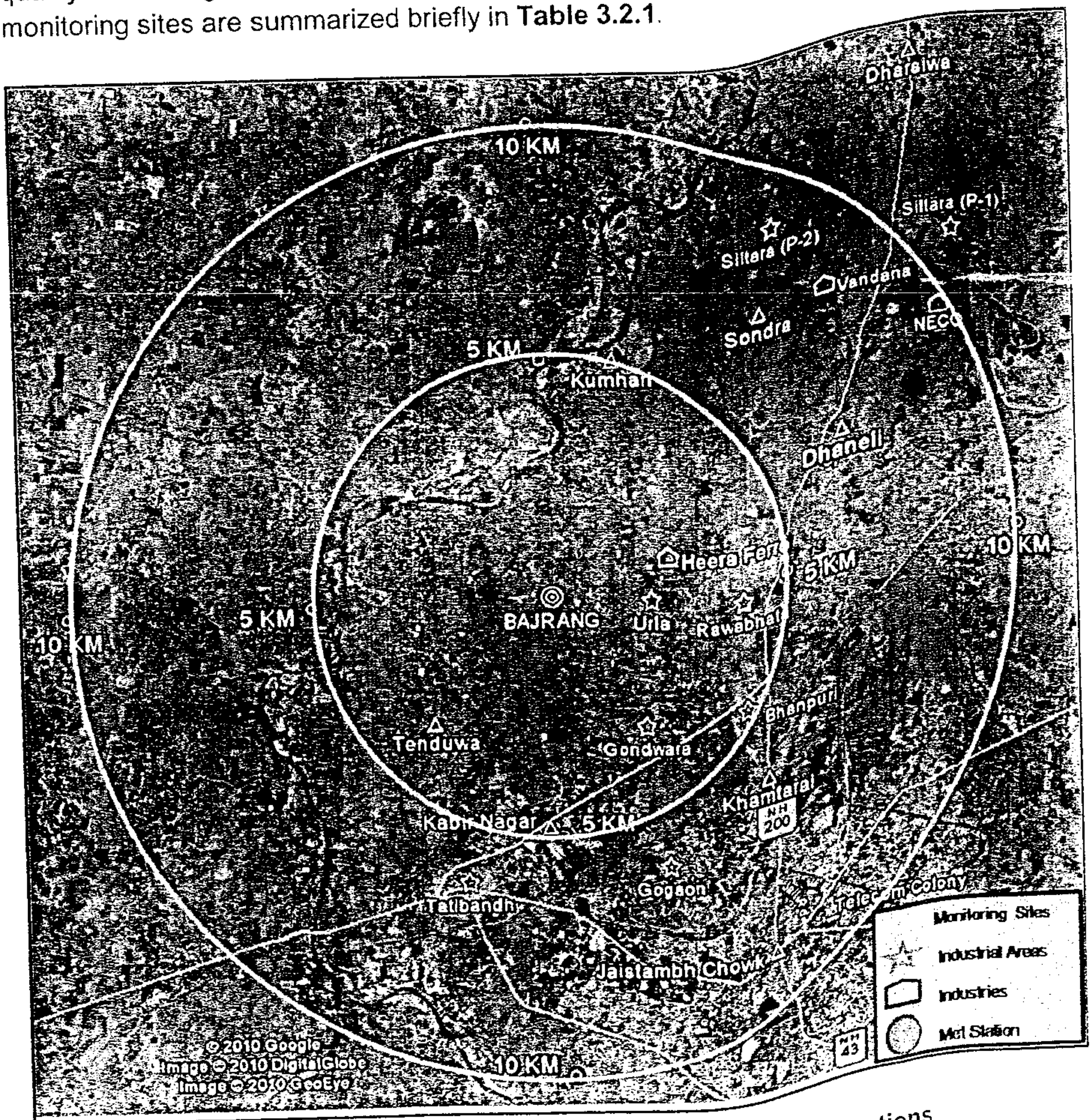


Plate 3.2.1: Locations of Ambient Air Quality Monitoring Stations

Table 3.2.1: Characteristics of Air Quality Monitoring Stations

Sr. No.	Monitoring Stations	Area Type	Site Description (within 1 km Arial zone)	Bearing (Latitude/ Longitude)
	Urban Sites			
1.	Jai Stambh Chowk	Residential/ commercial Area	Predominantly commercial activities, Number of hotels & restaurants exist, Residential area, High intensity traffic (mostly 2,3 & 4 wheelers)	21°14'37.99"N/ 81°38'6.51"E
2.	Khamtarai	Residential Area; urban	Residential area, Number of saw mills exist, Proximity to railway line, Slum area exists	21°16'37.47"N/ 81°38'13.94"E
3.	Kabir Nagar	Residential Area: urban	Mainly residential area (recently developed), National highway at about 300 m from the AQM site, Construction activities prevail	21°16'19.43"N/ 81°35'34.15"E
4.	Telecom Colony	Residential Area: urban	Residential area with congested colonies, Limited commercial activities, Low intensity traffic	21°14'7.76"N/ 81°39'11.85"E
	Rural Sites			
5.	Dhaneli (near Siltara Industrial Area - Phase I)	Residential Area : Rural	Rural area setting, Proximity to agricultural fields and national highway with high traffic around 500 m away from AQM site	21°20'18.20"N/ 81°39'11.80"E
6.	Sondra (near Siltara Industrial Area - Phase II)	Residential Area : Rural	Rural area setting, Proximity to large scale industries, Agricultural fields	21°21'52.21"N/ 81°38'31.19"E
7.	Kumhari	Residential Area: Rural	Rural area setting, Proximity to agricultural fields, Earthen pot making in the village, Brick kilns, Lies in the downwind of Industrial area	21°21'37.96"N/ 81°36'31.55"E
8.	Dharsiwa	Residential Area: Rural & Reference/ upwind site	Represent upwind site to the Siltara industrial area, Residential area, Proximity to agricultural fields and national highway with high traffic intensity	21°24'32.10"N/ 81°40'11.00"E

Out of the eight AAQM sites, Kabir Nagar site was close to national highway (NH 6) and the Urla industrial area. The highway carries heavy interstate and local traffic. Sondra was though near to the industries at Siltara Phase II industrial area but the vehicular activities were limited. Khamtarai represents a typical inner lane urban residential area whereas Jai Stambh Chowk (Poonam Hotel) site is in a busy commercial area, main market of Raipur city. Telecom Colony represents low income group residents of the city and Dhaneli and Sondra represent rural area, likely to be affected by the industrial emissions.

Kumhari was in downwind direction of the industrial area. Air quality monitoring station at Dharsiwa, with minimum impact of the industries and the traffic, was considered as the site representing the background air quality of the region, located in the upward direction of the industries.

3.2.2 Monitoring Parameters

Parameters of monitoring were decided keeping in view the study objectives. As the main objective of the study is to assess contribution of industrial emissions (mainly sponge iron, power plants, ferro alloys and steel rolling mills) to the ambient air quality of the region, therefore major criteria pollutants, particulate matter with their chemical speciation were primarily focused. Besides, other criteria pollutants, SO_2 and NO_2 were also monitored in order to know the regulatory compliance status.

RSPM/PM_{10} samples were collected on glass fiber filter paper of 8"x10" size in respirable dust sampler. Weight of dust samples collected at the bottom of cyclone were added to the dust collected on filter paper and the sum of both the dusts was considered as Total SPM. Gaseous pollutants were also monitored simultaneously. Sampling and analytical protocol used for monitoring of different pollutants is given in **Table 3.2.2**.

Table 3.2.2: Sampling and Analytical Protocol used in the Study

Parameters	SPM	RSPM/PM_{10}	SO_2	NO_2	Ions	Heavy metals
Sampling Instrument	Respirable Dust Sampler (RDS) with cyclone dust	Respirable Dust Sampler (RDS) with cyclone	Through tapping in the suction side of the RDS	Through tapping in the suction side of the RDS	Glass Fiber Filter paper installed at RDS	Glass Fiber Filter paper installed at RDS
Sampling Principle	Filtration of aero-dynamic sizes	Filtration of aero-dynamic sizes	Chemical absorption in suitable media	Chemical absorption in suitable media	Extraction by ultra sonication of a portion of the filter Paper	Extraction by acid digestion in a microwave oven of a portion of the filter Paper
Flow rate	1.0-1.4 m^3/min	1.0-1.4 m^3/min	0.5 lpm	0.5 lpm	--	--
Analytical Instrument	Electronic Balance	Electronic Balance	Spectro-photometer	Spectro-photometer	Ion Chromatograph	ICPAES
Analytical Method	Gravimetric	Gravimetric	Colorimetric, Improved West & Gaeke Method	Colorimetric, Jacobs & Hochheiser Modified method	Ion Chromatography	AES
Minimum Detectable Limit	5 $\mu g/m^3$	5 $\mu g/m^3$	4 $\mu g/m^3$	9 $\mu g/m^3$	0.1 $\mu g/m^3$	0.01 $\mu g/m^3$
Value Reporting	Complete number	Complete number	Complete number	Complete number	With one decimal place	With two decimal places

3.2.3 Monitoring Frequency

Various pollutants are emitted by different sources during different hours of the day, thereby exhibiting diurnal variations. Therefore, in order to assess the impact of the diurnal variations in sources as well as the typical meteorological changes in a day, it was decided to conduct 8 hrs monitoring during the time periods: 06-14 hrs, 14-22 hrs and 22-06 hrs so that the variations in activities of different sources as well as major meteorological settings of a typical day are represented in the monitoring results. The sampling duration for all the parameters was 8 hours and the daily average concentration was obtained by taking 3 observations of the 8 hourly average values for each pollutant.

In addition, grab samples (1 hour sampling) of ambient air were also collected in tedler bags for subsequent analysis for CO, methane and non-methane hydrocarbons (NMHCs).

3.3 Ambient Air Quality of Raipur Region: Analysis of Data

3.3.1 Statistical Summary of 24 hrly Average Concentration Levels

All the monitoring sites are divided into two broad categories as Urban sites and Rural sites. The monitoring sites at Jai Stambh Chowk, Khamtarai, Kabir Nagar and Telecom Colony are considered as Urban sites, whereas monitoring sites at Dhaneli, Sondra, Kumhari and Dharsiwa are considered as Rural sites. Dharsiwa site, being in the upwind direction is also considered as background site. Monitoring site-wise minimum, maximum, average and standard deviations in measured concentration levels of SPM, RSPM, SO_2 and NO_2 are presented in **Tables 3.3.1 & 3.3.2** respectively.

Table 3.3.1: 24 Hourly Average values of SPM and RSPM in Raipur Region: January 2009

Monitoring Site	SPM Concentration ($\mu g/m^3$)				RSPM Concentration ($\mu g/m^3$)			
	Min	Max	Avg	SD	Min	Max	Avg	SD
Urban Sites								
Jai Stambh Chowk	125	275	211	65	107	258	184	57
Khamtarai	158	328	243	63	150	257	187	36
Kabir Nagar	392	872	658	180	229	648	435	154
Telecom Colony	348	670	527	113	215	375	274	59
Rural Sites								
Dhaneli	346	631	462	108	170	316	234	56
Sondra	465	803	618	145	210	406	312	75
Kumhari	172	344	263	69	83	173	135	29
Dharsiwa	73	342	188	99	61	198	136	51
CPCB Standard	200*				100			

* As per earlier CPCB Standard

Perusal of **Table 3.3.1** indicates that the average SPM concentration was above the CPCB standard except at Dharsiwa, where it was 188 $\mu g/m^3$ minimum among all the monitoring sites. Here SPM concentrations were in the range of 73 to 342 $\mu g/m^3$ with standard deviation of 99 $\mu g/m^3$. Maximum average SPM concentration to the tune of 658 $\mu g/m^3$ was observed at Kabir Nagar followed by Sondra (618 $\mu g/m^3$) and Telecom Colony (527 $\mu g/m^3$). Maximum standard deviation of 180 $\mu g/m^3$ was observed at Kabir Nagar followed by Sondra (145 $\mu g/m^3$) and Telecom Colony (113 $\mu g/m^3$). This fluctuation could perhaps be due to traffic density and the excessive loose soil around the sampling sites. Besides this, Kabir Nagar site is also in proximity to Urla industrial area. The standard deviation in SPM at JS Chowk and Khamtarai is minimum, 65 µg/m^3 and 63 µg/m^3 respectively, because of all paved roads and concrete buildings all around.

The average RSPM concentration was observed to be above the CPCB standard at all the monitoring sites. The average value exceeded by 1.35 time (at Kumhari) to 4.35 times (at Kabir Nagar). At Dharsiwa, though few observations were below the standard, but the average of all the values during the monitoring period was observed to be above the CPCB standard. The standard deviation values ranged from 29 µg/m^3 (at Kumhari) to 154 µg/m^3 (at Kabir Nagar). At all other sites, the SD was within this range. The high fluctuation in fine particulate matter at Kabir Nagar could be due to heavy traffic density as National Highway is just about 300 meters from the sampling site, and also due to construction activities going on in that area.

Statistical summary of 24 hourly average values of gaseous pollutants (SO_2 and NO_2) are given in **Table 3.3.2.** Average concentration of both the gaseous pollutants was observed within the permissible level of 80 µg/m^3. Highest average concentration of SO_2 (51 µg/m^3) and NO_2 (49 µg/m^3) was observed at Jai Stambh Chowk. In general, even maximum values were found within the limit at all the monitoring sites, except SO_2 at Jai Stambh Chowk (89 µg/m^3) and NO_2 at Dhaneli (82 µg/m^3). Among all the monitoring sites, lowest 24 hourly average concentrations were found at Dharsiwa (13 µg/m^3 for SO_2 and 19 µg/m^3 for NO_2).

Table 3.3.2: 24 Hrly Average values of SO_2 and NO_2 in Raipur Region: January 2009

Monitoring Site	SO_2 Concentration (µg/m^3)				NO_2 Concentration (µg/m^3)			
	Min	Max	Avg	SD	Min	Max	Avg	SD
Urban Sites								
Jai Stambh Chowk	18	89	51	23	13	61	49	20
Khamtarai	13	49	32	15	8	62	37	39
Kabir Nagar	8	45	24	13	6	67	38	23
Telecom Colony	6	46	19	14	29	61	43	12
Rural Sites								
Dhaneli	25	62	38	14	13	82	47	25
Sondra	12	42	29	10	22	62	45	16
Kumhari	11	55	26	16	32	62	43	12
Dharsiwa	7	21	13	5	6	35	19	10
CPCB Standard	80				80			

Average concentration levels of particulate matter (SPM & RSPM/PM_{10}) and gaseous pollutants (SO_2 and NO_2) along with their respective CPCB Standards are presented in **Figs. 3.3.1 and 3.3.2**, respectively.

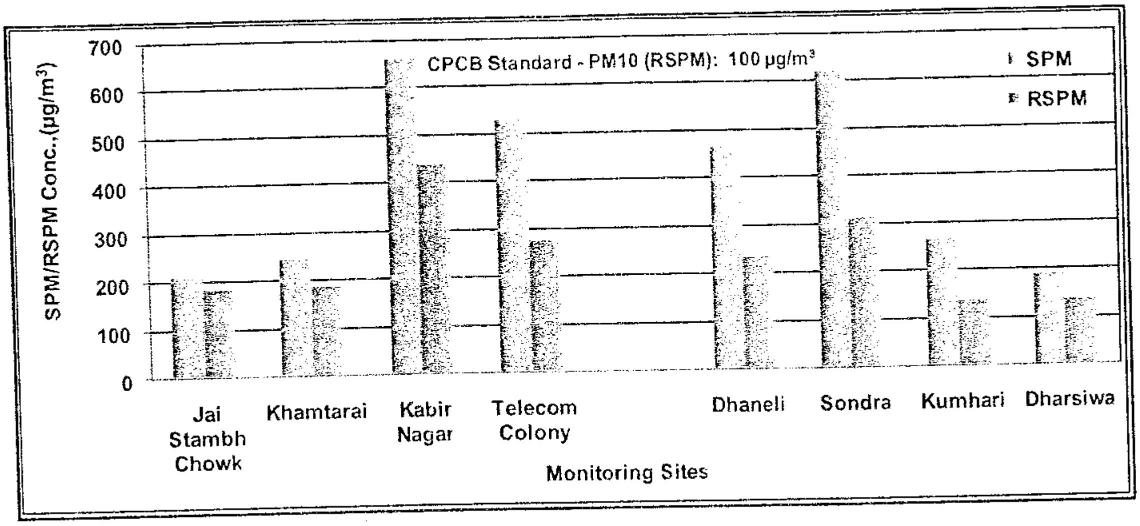


Fig. 3.3.1: 24 Hourly Average Concentrations of SPM and RSPM in Raipur Region

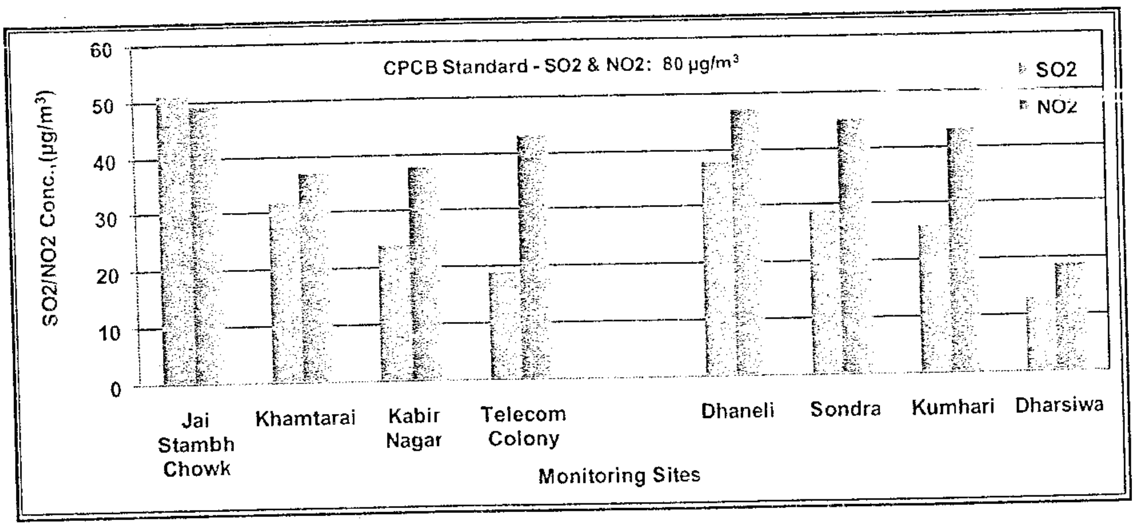


Fig. 3.3.2: 24 Hourly Average Concentrations of SO_2 and NO_2 in Raipur Region

It is observed that average concentration levels of RSPM exceeded at all monitoring locations with exceedence factor of 1.35 to 4.35. Among the urban sites, Kabir Nagar recorded the highest RSPM levels, whereas Jai Stambh Chowk recorded lowest RSPM levels. Among rural sites, highest levels were recorded at Sondra, followed by Dhaneli and lowest at Dharsiwa. Average concentration levels of SO_2 and NO_2, both were found to be well within the permissible levels of 80 µg/m³, highest being at Jai Stambh Chowk and lowest at Dharsiwa. The average concentration levels of SO_2 and NO_2 were found to be in similar range both in urban and rural areas.

3.3.2 Site-wise 8 hourly Variations in Ambient Air Quality

Monitoring site wise diurnal variations in concentration of particulate matter and gaseous pollutants during the study period is presented in **Tables 3.3.3 & 3.3.4** respectively and graphically shown in **Figs. 3.3.3 to 3.3.5** for the three criterion pollutants, RSPM (PM_{10}), SO_2 and NO_2.

Table 3.3.3: 8 Hourly Average Concentrations of RSPM and SPM in Raipur Region (January 21-28, 2009)

Monitoring Site	8 Hourly Average RSPM Concentration (µg/m³)			8 Hourly Average SPM Concentration (µg/m³)		
	06-14 hrs	14-22 hrs	22-06 hrs	06-14 hrs	14-22 hrs	22-06 hrs
Urban Sites						
Jai Stambh Chowk	131	230	189	149	251	215
Khamtarai	171	177	201	240	238	281
Kabir Nagar	391	556	331	719	720	547
Telecom Colony	210	324	290	539	555	493
Rural Sites						
Dhaneli	252	210	234	557	427	415
Sondra	326	345	328	622	504	580
Kumhari	156	160	100	277	293	218
Dharsiwa	127	126	162	302	144	270

Table 3.3.4: 8 Hourly Average Concentrations of SO_2 and NO_2 in Raipur Region (January 21-28, 2009)

Monitoring Site	8 Hourly Average SO_2 Concentration (µg/m³)			8 Hourly Average NO_2 Concentration (µg/m³)		
	06-14 hrs	14-22 hrs	22-06 hrs	06-14 hrs	14-22 hrs	22-06 hrs
Urban Sites						
Jai Stambh Chowk	41	41	52	52	41	53
Khamtarai	44	27	32	21	42	18
Kabir Nagar	27	24	20	30	57	29
Telecom Colony	27	15	17	30	54	46
Rural Sites						
Dhaneli	50	40	28	38	37	54
Sondra	37	28	18	35	51	45
Kumhari	63	25	10	37	51	38
Dharsiwa	11	15	12	24	23	17

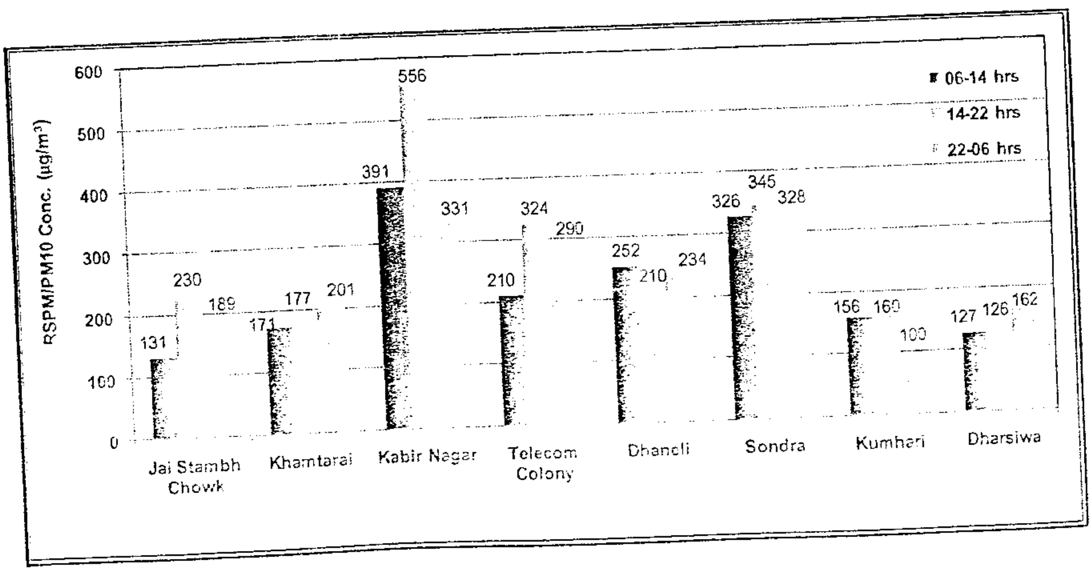


Fig. 3.3.3: Diurnal Variation in 8 Hourly Average Concentrations of RSPM in Raipur Region

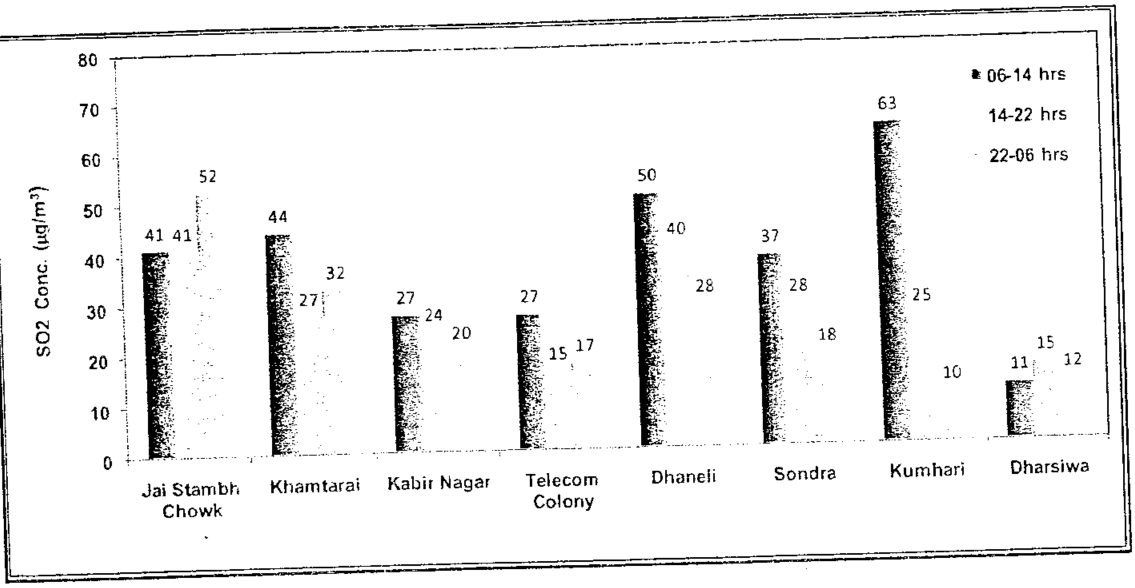


Fig. 3.3.4: Diurnal Variation in 8 Hourly Average Concentrations of SO_2 in Raipur Region

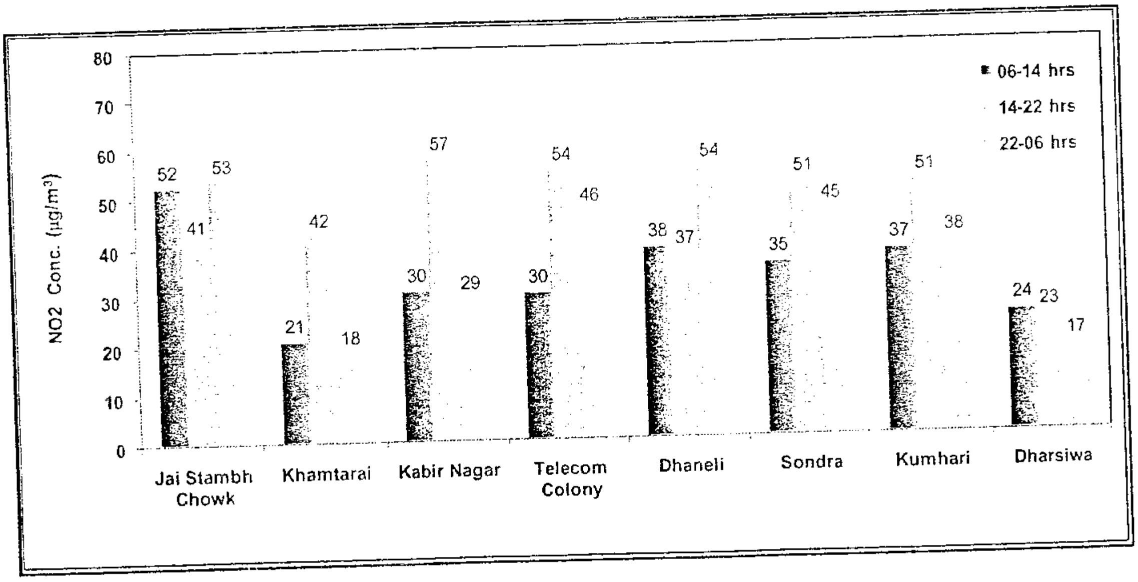


Fig. 3.3.5: Diurnal Variation in 8 Hourly Average Concentrations of NO_2 in Raipur Region

Perusal of diurnal variations in RSPM levels (**Fig. 3.3.3**) indicates wide fluctuations at most of the air quality monitoring sites, maximum being at Kabir Nagar, Telecom Colony and Jai Stambh Chowk (all urban sites), whereas diurnal variations are less fluctuating at rural sites. Highest values are observed during 14-22 hrs at Jai Stambh Chowk, Kabir Nagar, Telecom Colony, Sondra and Kumhari, which may be attributed to various commercial/residential and also industrial activities during day/evening time periods. At Khamtarai and Dharsiwa, highest levels were observed during night hours (22-06 hrs), whereas at Dhaneli, highest level was observed during morning/noon hours (06-14 hrs).

Diurnal variations in SO_2 levels shown in **Fig. 3.3.4** indicate in general highest levels of SO_2 during morning/noon hours at Khamtarai, Kabir Nagar, Telecom Colony, Dhaneli, Sondra and Kumhari (6 out of 8 sites). This may be attributed to day-to-day routine activities starting at early morning till noon, involving combustion of fuel mainly coal for various commercial/residential as well as industrial purposes.

In general, lesser concentration levels are observed during night hours (22-06 hrs), except at Jai Stambh Chowk, wherein highest level is observed during night hours. This may be attributed to the combustion of coal in nearby hotels and restaurants, especially during night hours or early morning hours. The 8 hrly average values of SO_2 ranged between 10 µg/m^3 (22-06 hrs) to 63 µg/m^3 (06-14 hrs), both at Kumhari. In Kumhari village, several houses are involved in making earthen lamps/pots. For baking of these pots, lot of coal and other fuels are burned, that result in higher levels of SO_2 during morning/noon hours.

Also at Dhaneli, the site was located near a farm house. The local people use coal and cow dung to meet their energy need and their activities are reflected in high concentration of SO_2 during 06-14 hrs. Further these two locations were also near to the industrial estate, contributing to SO_2 in the region.

Diurnal variations in NO_2 levels shown in **Fig. 3.3.5** indicate that in general highest levels occurred during 14-22 hrs (5 out of 8 sites). Among all sites, highest concentrations occurred during 14-22 hrs at Kabir Nagar, however the levels are in the similar range at other locations as well. During 06-14 hrs, NO_2 levels varied from 21 µg/m^3 at Khamtarai to 52 µg/m^3 at Jai Stambh Chowk. During 14-22 hrs, it varied from 23 µg/m^3 at Dharsiwa to 57 µg/m^3 at Kabir Nagar and during night hours (22-06 hrs), it varied from 17 µg/m^3 at Dharsiwa to 53 µg/m^3 at Jai Stambh Chowk. In general, the NO_2 concentration levels were reasonably comparable during daytime (06-14 hrs) and night hours (22-06 hrs) at many locations.

3.3.3 Status of Specific Pollutants in the Region

One hour average concentration level of specific gaseous pollutants, CO and total Hydrocarbon (THC including methane & non-methane) during the study period are presented in **Table 3.3.5.**

Table 3.3.5: Concentration Levels of CO, HC, Methane and non-Methane in Raipur Region (September 2009)

Monitoring Site	CO (ppm)	THC (ppm)	CH_4 (ppm)	Non-CH_4 (ppm)
Jai Stambh Chowk	2.194	8.91	3.49	5.42
Khamtarai	0.389	5.17	2.52	2.65
Kabir Nagar	0.174	5.53	2.23	3.30
Telecom Colony	0.365	5.32	2.35	2.95
Dhaneli	0.167	5.01	2.42	2.59
Sondra	0.182	4.23	2.21	2.02
Kumhari	0.218	4.56	2.22	2.34
Dharsiwa	0.217	4.70	2.45	2.25

Concentration of CO (2.194 ppm) and total hydrocarbons (8.91 ppm) were recorded to be highest at Jai Stambh Chowk. At other locations, concentrations were below 0.4 ppm and 5.6 ppm, respectively for CO and THC. Comparative status of concentration levels of CO and hydrocarbons (THC, CH_4 and non-CH_4) is depicted in **Figs. 3.3.6 & 3.3.7**, respectively.

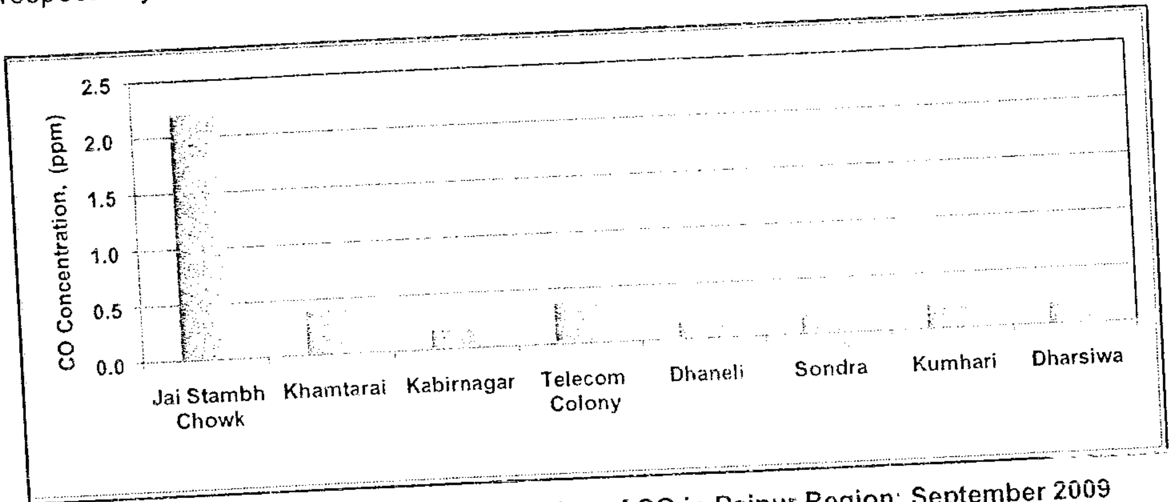


Fig. 3.3.6: Hourly Average Concentration of CO in Raipur Region: September 2009

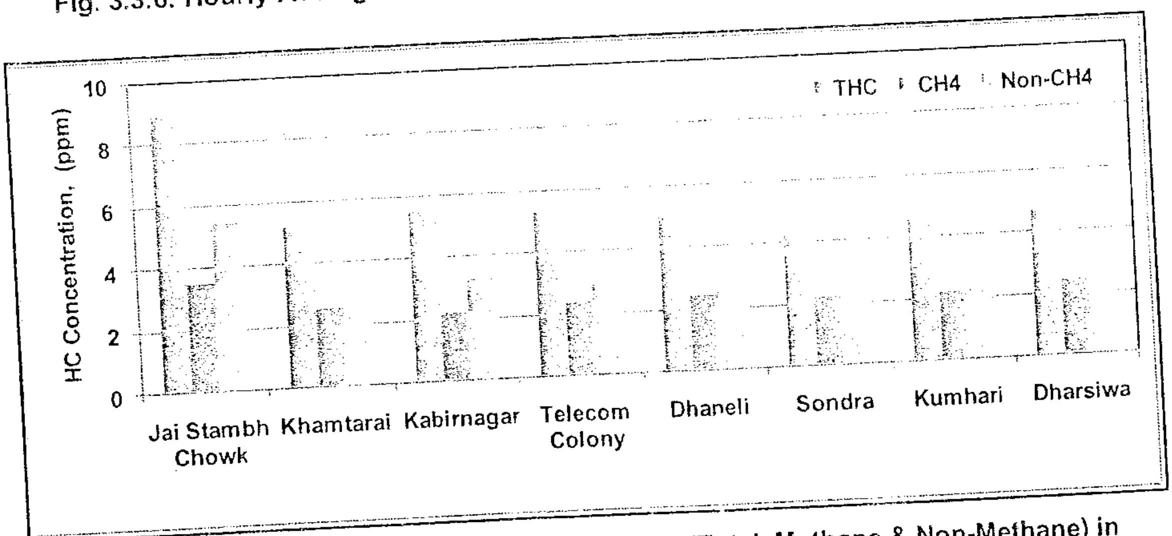


Fig. 3.3.7: Hourly Average Concentration of HCs (Total, Methane & Non-Methane) in Raipur Region: September 2009

3.4 Chemical Speciation of Ambient Particulate Matter (All Sites)

In order to assess the impact of industrial activities on air quality of Raipur region, it was decided to further characterize the respirable particulate matter collected during ambient air quality monitoring. The parameters chosen for this purpose were inorganic in nature as the impact was expected for heavy metals contamination, anions & cations to RSPM due to fine particle emanating from the industries either from stack or fugitive dust and local re-suspended soil dust. Iron being one of the crustal elements and also present in source along with other elements namely copper, lead and manganese, it was decided to analyze RSPM and thimbles dust collected during stack monitoring for ions and heavy metals.

Dust samples collected in the thimble and RSPM filter papers were all treated exactly in the same manner. For anions and cations a portion of the filter paper was sonicated in double distilled water and filtered through 0.4 micron PTFE filter and then injected in Dionex Ion chromatograph. AS-11 and CS-12 column followed by electrolytic suppression of the background conductivity of the carrier solution were used for determining anions and cations in the samples.

For heavy metals, another portion of the same filter paper was digested with concentrated nitric acid in a microwave oven and filtrate was analyzed on ICP AES. Since it was difficult to dislodge the dust stuck to the thimbles, these were cut exactly in to two parts to get sample for ions and heavy metals analysis. Both the parts of thimble were treated exactly in the same manner as RSPM filter papers.

Concentration levels of cations, anions and heavy metals were estimated by taking three 8 hourly samples of a day. Two days filter papers representing working day and non-working day, were analyzed for chemical characterization. The results of chemical characterization of filter papers are presented in the following sub-section

3.4.1 Cations in Ambient Air

Concentration levels of cations (Na^+, K^+, Ca^{2+}, Mg^{2+} and NH_4^+) along with measured RSPM concentration on working (Day 1) and non-working day (Day 2) are given in **Table 3.4.1**, and also graphically presented in **Figs. 3.4.1** and **3.4.2,** respectively for Urban and Rural sites.

Concentrations of Na^+ and Ca^{2+} were found to be dominant at all the sites, highest being at Kabir Nagar and Telecom Colony. High levels of Ca^{2+} could be due to construction of roads and buildings activities in the area or it could be soil originated as substantiated by the presence of Na^+ and K^+. In general, at urban sites, concentration levels of all the Cations were higher on working day, as compared to the non-working day. At Rural sites also, Na^+ and Ca^{2+} were found to be more, highest being at Sondra. Among rural sites, at some locations, no specific trend of working and non-working day was observed.

Table 3.4.1: Concentration of Cations in RSPM (PM_{10}) Samples in Raipur Region

Sampling Site	Sample Day	Cations Concentration (µg/m³)					RSPM Conc. (µg/m³)
		Na^+	K^+	Ca^{2+}	Mg^{2+}	NH_4^+	
Urban Sites							
Jai Stambh Chowk	Day 1	13.20	3.35	10.32	0.42	3.44	258
	Day 2	11.40	3.44	4.07	0.00	5.68	107
Khamtarai	Day 1	12.48	3.47	5.74	0.54	1.79	213
	Day 2	8.74	2.92	4.40	0.00	1.49	150
Kabir Nagar	Day 1	11.72	4.88	22.47	2.39	3.74	611
	Day 2	10.24	3.39	19.98	0.85	5.11	241
Telecom Colony	Day 1	18.43	5.25	18.38	1.27	4.17	222

	Day 2	13.79	4.57	11.07	0.49	2.35	223
Rural Sites							
Dhaneli	Day 1	8.88	2.53	5.27	0.63	0.99	196
	Day 2	11.13	3.10	10.08	1.98	4.73	194
Sondra	Day 1	20.11	4.88	7.55	1.82	3.08	280
	Day 2	13.92	5.34	17.46	0.66	5.22	406
Kumhari	Day 1	10.74	3.25	10.82	0.62	6.34	141
	Day 2	7.76	2.63	3.44	0.17	3.42	160
Dharsiwa	Day 1	10.86	2.77	5.82	0.56	2.05	97
	Day 2	10.14	2.82	7.76	0.57	4.97	163

(Day 1- Working day; Day 2- Non-working day)

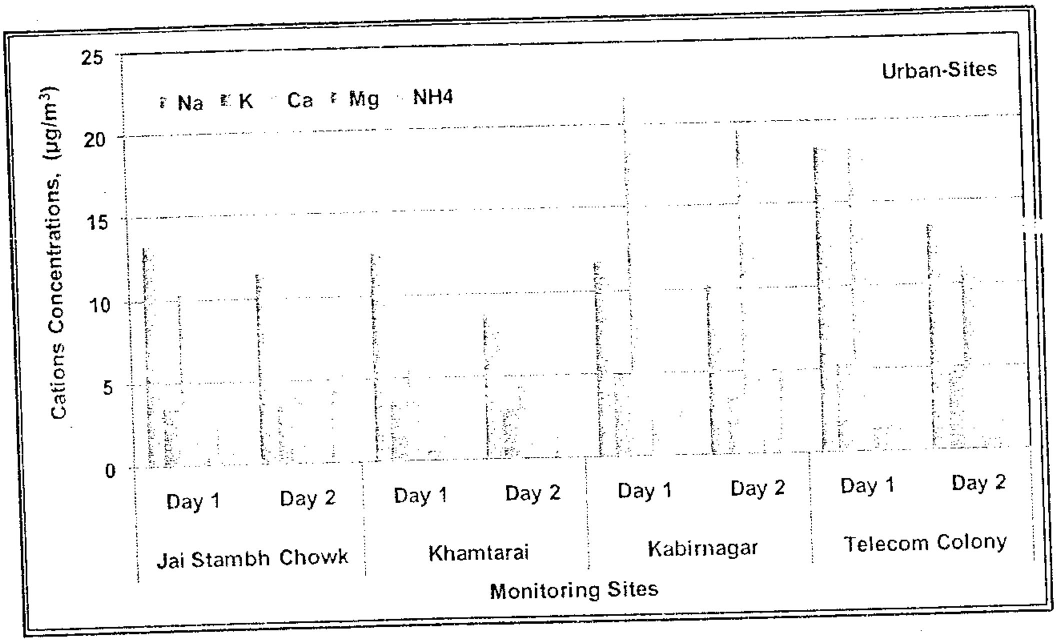


Fig. 3.4.1: Concentration of Cations in RSPM Samples of Raipur Region: Urban Sites

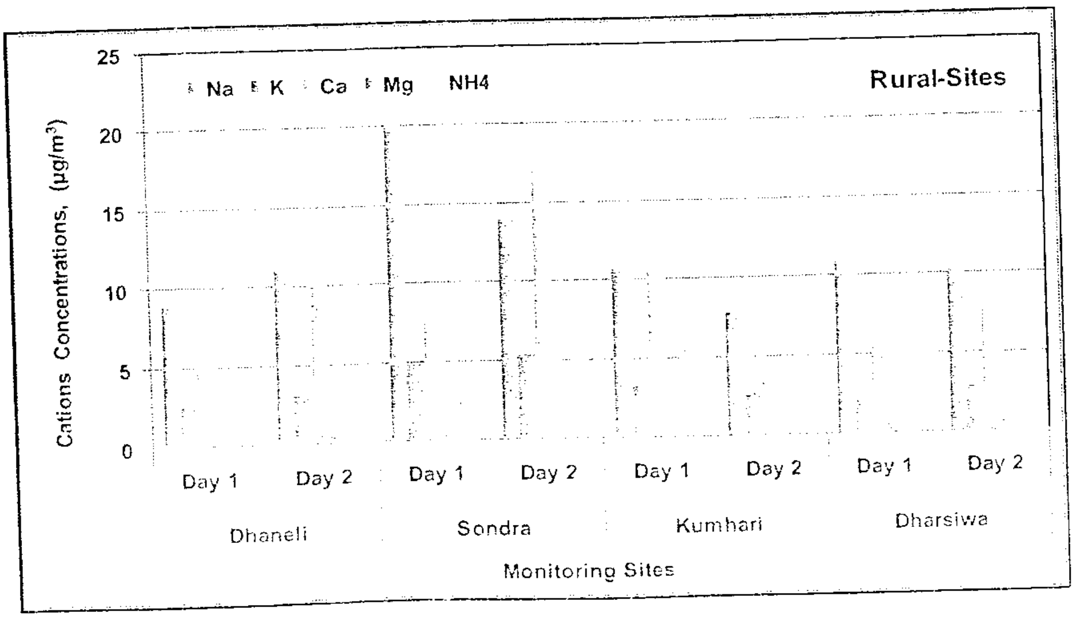


Fig. 3.4.2: Concentration of Cations in RSPM Samples of Raipur Region: Rural Sites

3.4.2 Anions in Ambient Air

Concentration levels of anions (SO_4^{2-}, NO_3^-, Cl^- and F^-) along with measured RSPM concentration on working (Day 1) and non-working day (Day 2) are given in **Table 3.4.2**, and also graphically presented in **Figs. 3.4.3** and **3.4.4**, respectively for Urban and Rural sites.

Table 3.4.2: Concentration of Anions in RSPM (PM_{10}) Samples in Raipur Region

Sampling Site	Sample Day	Anions Concentration (µg/m³)				RSPM Conc. (µg/m³)
		SO_4^{2-}	NO_3^-	Cl^-	F^-	
Urban Sites						
Jai Stambh Chowk	Day 1	15.24	8.68	13.49	0.80	258
	Day 2	15.22	6.40	8.69	0.34	107
Khamtarai	Day 1	24.76	8.21	10.89	0.40	213
	Day 2	16.19	6.28	11.82	0.45	150
Kabir Nagar	Day 1	28.91	17.69	19.48	1.54	611
	Day 2	58.95	18.48	13.69	1.06	241
Telecom Colony	Day 1	20.45	10.88	13.19	0.37	222
	Day 2	34.12	14.12	18.84	0.72	223
Rural Sites						
Dhaneli	Day 1	14.89	5.28	18.34	1.11	196
	Day 2	14.25	5.95	12.91	0.89	194
Sondra	Day 1	16.96	3.34	11.46	0.98	280
	Day 2	32.52	15.26	18.50	1.27	406
Kumhari	Day 1	11.87	3.57	12.97	0.63	141
	Day 2	16.11	4.97	10.97	0.46	160
Dharsiwa	Day 1	9.19	2.89	8.40	0.19	97
	Day 2	9.60	4.14	7.26	0.25	163

(Day 1- Working day; Day 2- Non-working day)

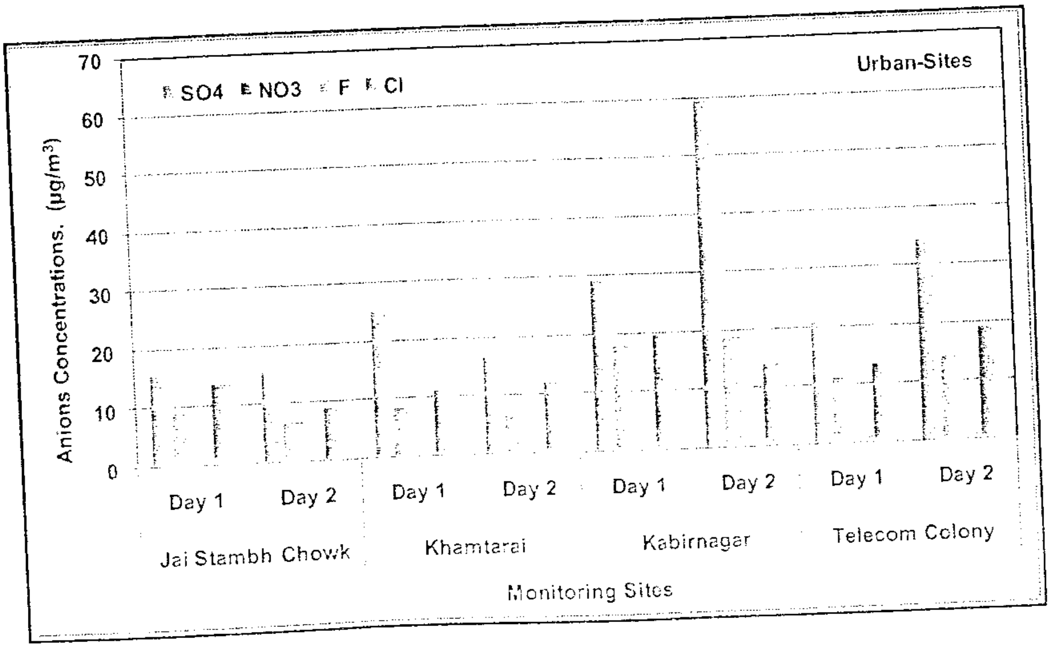


Fig. 3.4.3: Concentration of Anions in RSPM Samples of Raipur Region: Urban Sites

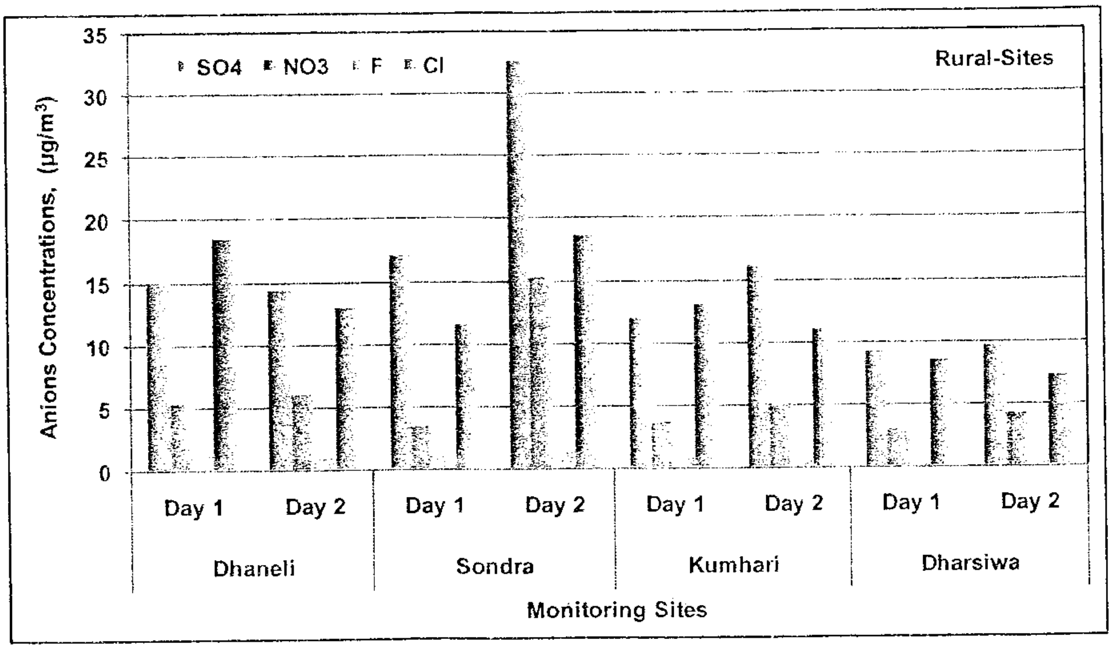


Fig. 3.4.4: Concentration of Anions in RSPM Samples of Raipur Region: Rural Sites

Concentrations of SO_4^{2-}, NO_3^- and Cl^- were found to be dominant at all the sites, highest being at Kabir Nagar among urban sites and at Sondra among the rural sites. The proximity of these two places to the industrial activities generating SO_2 and in turn the formation of Sulfate as a secondary pollutant and the road construction at Kabir Nagar is reflected in these results. At Telecom Colony, presence of Sulfate could be attributed to the use of coal. Among all the sites, no specific trend of working and non-working day was observed.

3.4.3 Heavy Metals in Ambient Air

Heavy metals in urban and rural air monitoring sites are shown in **Table 3.4.3** and are presented in **Figs. 3.4.5** and **3.4.6**, respectively.

Table 3.4.3: Concentration of Heavy Metals in RSPM (PM_{10}) Samples in Raipur Region

Sampling Site	Day	Heavy Metals Concentration (µg/m³)					RSPM Conc. (µg/m³)
		Fe	Cu	Pb	Mn	Zn	
Urban Sites							
Jai Stambh Chowk	Day 1	5.55	0.00	0.16	0.00	21.00	258
	Day 2	1.82	0.02	0.00	0.00	4.56	107
Khamtarai	Day 1	4.26	0.01	0.00	0.00	19.14	213
	Day 2	2.94	0.08	0.35	0.00	11.03	150
Kabir Nagar	Day 1	26.53	2.16	0.04	0.00	20.54	611
	Day 2	8.31	1.56	0.03	0.00	12.55	241
Telecom Colony	Day 1	5.40	0.01	BDL	0.00	21.08	222
	Day 2	5.51	0.06	BDL	0.00	21.00	223

Rural Sites							
Dhaneli	Day 1	8.24	0.00	0.01	0.00	17.84	196
	Day 2	5.86	0.04	0.19	0.00	7.90	194
Sondra	Day 1	9.95	1.44	BDL	0.00	31.31	280
	Day 2	16.68	0.82	0.13	0.00	10.29	406
Kumhari	Day 1	3.45	1.01	BDL	0.00	10.00	141
	Day 2	4.23	0.05	0.05	0.00	8.28	160
Dharsiwa	Day 1	3.45	BDL	BDL	0.00	9.08	97
	Day 2	7.06	0.14	BDL	0.00	12.65	163

(Day 1- Working day; Day 2- Non-working day)

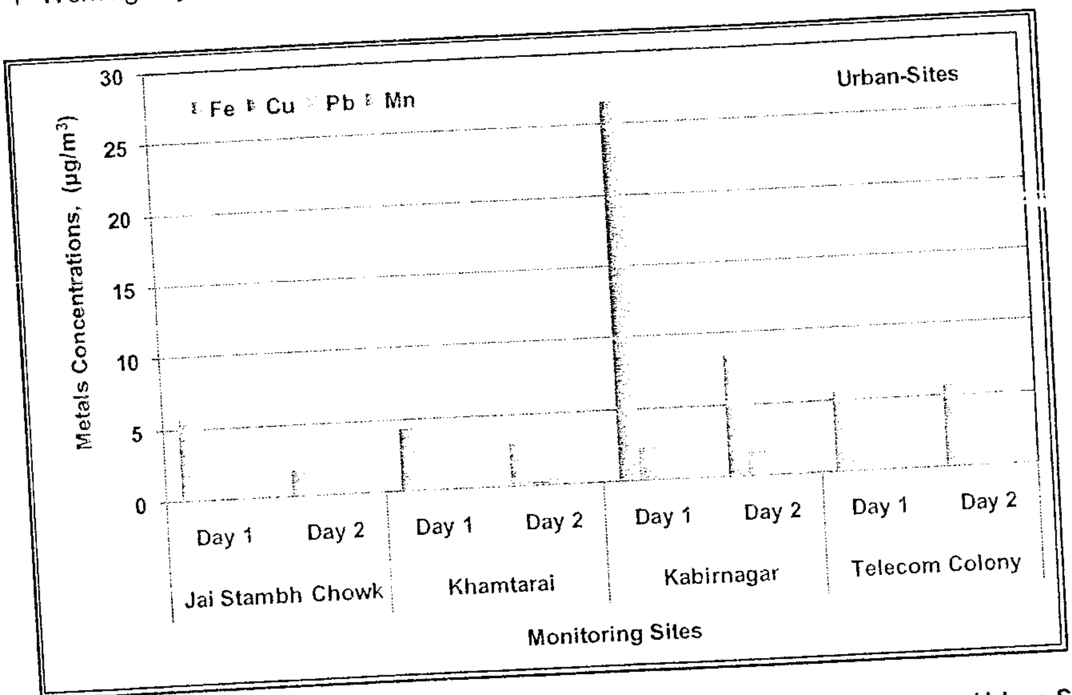


Fig. 3.4.5: Concentration of Heavy Metals in RSPM Samples of Raipur Region: Urban Sites

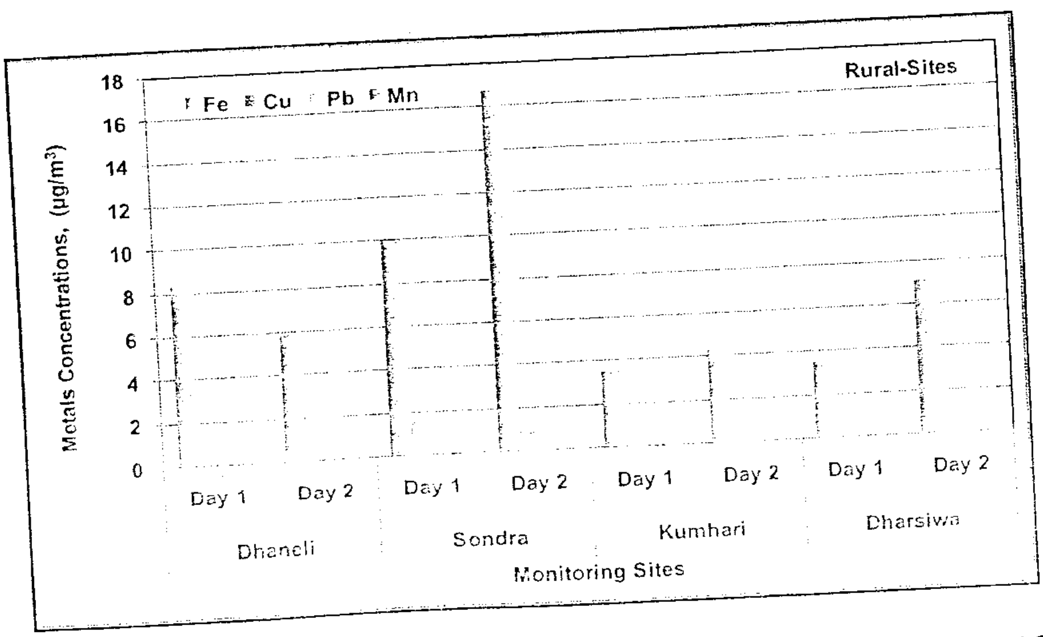


Fig. 3.4.6: Concentration of Heavy Metals in RSPM Samples of Raipur Region: Rural Sites

It is observed that among all the sites, Iron content was highest at Kabir Nagar and Sondra on both the days. Copper is also detected here on these days. It is also detected in Kumhari on 1st day. Zinc is also observed in substantial concentration at all the sites. The industrial impact is evident by the presence of metals in measured ambient RSPM samples at Kabir Nagar and Sondra monitoring sites. Other heavy metals (Cd, Cr, Co & Ni) were below detectable limits (BDL).

Summary of chemical characterization of RSPM samples in terms of Cations, Anions and Heavy metals collected at Urban and Rural sites is presented in **Tables 3.4.4 and 3.4.5**.

Table 3.4.4: Concentration of Cations, Anions and Heavy Metals in Ambient RSPM Samples

Sampling Site	Concentration, (μg/m^3)				
	Average RSPM	Total Cations	Total Anions	Total Metals	Total Identified Mass
Urban Sites	253	32.7	52.8	24.8	110.3
Rural Sites	205	28.4	34.7	21.5	84.6
Average of all Sites	**229**	**30.5**	**43.8**	**23.1**	**97.4**

Table 3.4.5: Percentage Share of Cations, Anions and Heavy Metals in Ambient RSPM Samples

Sampling Site	% Share				
	Cations	Anions	Metals	Identified Mass	Unidentified Mass
Urban Sites	14.7	23.6	9.9	48.2	51.8
Rural Sites	15.2	17.7	10.8	43.7	56.3
Average of all Sites	**14.9**	**20.6**	**10.4**	**45.9**	**54.1**

Of the total average RSPM concentration of 253 μg/m^3 at Urban sites, chemical constituents identified are 110.3 μg/m^3, which is 48.2% of the total measured RSPM concentration. Similarly, at Rural sites, out of RSPM concentration of 205 μg/m^3, identified chemical constituents are 43.7%. The remaining mass could be elemental carbon, organic carbon, silica and many other ions and metals.

Based on the monitored levels of ambient air quality parameters in Raipur region, the three most affected sites are identified, as presented in **Table 3.4.6**. Perusal of the Table indicates that Kabir Nagar, Telecom Colony, Sondra and Dhaneli are the most affected sites/areas.

Table 3.4.6: Ranking of Monitoring Sites in terms of Air Quality Parameters and Chemical Speciation of Particulate Matter

	Ranking as Highest Level		
Parameters	**First**	**Second**	**Third**
Air Quality			
RSPM/PM10	Kabir Nagar	Sondra	Telecom Colony
SPM	Kabir Nagar	Sondra	Telecom Colony
Sulfur dioxide (SO_2)	Jai Stambh Chowk	Dhaneli	Khamtarai
Nitrogen dioxide (NO_2)	Jai Stambh Chowk	Dhaneli	Sondra
Cations			
Sodium (Na^+)	Sondra	Telecom Colony	JS Chowk
Potassium (K^+)	Sondra	Telecom Colony	Kabir Nagar
Calcium (Ca^{2+})	Kabir Nagar	Telecom Colony	Sondra
Magnesium (Mg^{2+})	Kabir Nagar	Dhaneli	Sondra
Ammonium (NH_4^+)	Kumhari	Jai Stambh Chowk	Kabir Nagar
Anions			
Sulfate (SO_4^{2-})	Kabir Nagar	Telecom Colony	Sondra
Nitrate (NO_3^-)	Kabir Nagar	Telecom Colony	Sondra
Chloride (Cl^-)	Kabir Nagar	Sondra	Dhaneli
Fluoride (F^-)	Kabir Nagar	Telecom Colony	Dhaneli
Heavy Metals			
Iron (Fe)	Kabir Nagar	Sondra	Dhaneli
Copper (Cu)	Kabir Nagar	Sondra	Kumhari
Lead (Pb)	Khamtarai	Dhaneli	Sondra
Manganese (Mn)	--	--	--
Zinc (Zn)	Kabir Nagar	Sondra	Telecom Colony

In order to establish linkage between chemical constituents present in ambient air to those emitted from the industries, chemical speciation of particulate matter in stacks of different type of industries is carried out, which is discussed in the next Chapter.

Chapter 4

Stack Emission Characterization

Chapter 4

Stack Emission Characterization

4.1 Details of Representative Industries

Stack emission monitoring was carried out in selected industries, representative of sponge iron, power plant, ferro alloy and rolling mills falling in Siltara, Urla, Tatibandh, Borjhara and Tenduwa industrial areas of Raipur region. For monitoring of particulate matter concentrations in the stacks, the representative industries were selected in consultation with CECB, Raipur. Monitoring was carried out by NEERI during January-February 2009, using Stack Monitoring Kit, VSS 1 (Vayubodhan Upkaran Pvt. Ltd, New Delhi) and following the protocol prescribed in IS: 11255 (Part I)-1985 of Bureau of Indian Standards (BIS).

In all 19 stacks attached to various processes, representing sponge iron, power plant, ferro alloy and rolling mills were monitored in 9 industries, as detailed in **Table 4.1.1**.

Table 4.1.1: List of Selected Representative Industries for Stack Monitoring

Type of Industry & Region	Name of Industry	No. of Stacks Monitored
Sponge Iron Plants (Siltara Industrial Area)	M/s Godawari Power & Ispat Ltd.	2
	M/s Sarda Energy & Minerals Ltd.	2
	M/s PD Industries Pvt. Ltd.	1
	M/s Rashmi Sponge Iron Pvt. Ltd.	1
Captive Power Plants (Siltara/Urla Industrial Area)	M/s Godawari Power & Ispat Ltd.	1
	M/s Sarda Energy & Minerals Ltd.	2
	M/s Rashmi Sponge Iron Pvt. Ltd.	1
	M/s Indsil Energy and Electro-chemicals Ltd.	1
Ferro Alloys (Urla/ Siltara Industrial Area)	M/s Indsil Energy and Electro-chemicals Ltd.	2
	M/s Raghuveer Ferro Alloys Pvt. Ltd.	1
	M/s Sarda Energy & Minerals Ltd.	1
Rolling Mills (Tatibandh Area)	Shriram Steels	1
	Krishna Steels	2
	Shriniwas Maruti Steels	1

The industries were selected as the representative ones for (i) Sponge Iron plants making sponge iron from iron ore, (ii) Captive power plants producing power from coal and waste heat (WHRB) for in-house consumption or limited external supply in the region, (iii) Ferro alloy plants making silico manganese materials from relevant rocks and minerals, and (iv) Rolling Mills making iron bars, angles and bends from iron ingots.

A summary of the selected industries with details of input materials, stack characteristics and pollution control equipment with efficiency are given in **Table 4.1.2** through **Table 4.1.5** respectively for Sponge Iron Industries, Power Plants, Ferro Alloy Industries and Rolling mills.

Table 4.1.2: Details of Representative Sponge Iron Industries Selected for Stack Monitoring

Sr. No.	Name of Industry	Stack attached to Process	Raw Material Used	Stack Height (m)	Stack Diameter (m)	Air Pollution Control Equipment	Particulate Matter Conc. (mg/Nm^3)
1.	Godavari Power and Ispat Ltd.	SIP-1 & 2	Iron Ore + Coal + Dolomite	70	2.4	ESP with 99% Efficiency	46
2.	Sarda Energy and Minerals Ltd.	SIP, sister stack -1 & 2	Iron Ore + Coal + Limestone/ Dolomite + LDO	65	3.92	WHRB along with ESP with 98.5% Efficiency	48
3.	PD Industries	SIP, DRI process	Iron Ore + Coal + Dolomite	44	3.01	ESP	85
4.	Rashmi Sponge Iron and Power Ind. Ltd.	SIP, DRI process	Iron Ore + Coal + Dolomite	55	3.65	ESP with 99.75% efficiency	73

Table 4.1.3: Details of Representative Captive Power Plants Selected for Stack Monitoring

Sr. No.	Name of Industry	Stack attached to Process	Raw Materia l Used	Stack Height (m)	Stack Diameter (m)	Air Pollution Control Equipment	Particulate Matter Conc. (mg/Nm^3)
1.	Godavari Power and Ispat Ltd.	Power Plant (WHRB + AFBC)	Coal	70	2.2	ESP with 99% Efficiency	40-45
2.	Sarda Energy and Minerals Ltd.	CPP Boiler	Coal + LDO	90	3.3	ESP with 290 TPH AFBC Boiler 98.5% Efficiency	46
3.	Sarda Energy and Minerals Ltd.	Power Plant, WHRB	Coal	42.5	3.9	WHRB along with ESP with 98.5% Efficiency	49
4	Rashmi Sponge Iron and Power Ind. Ltd.	Power, FBC	Coal + Dolo-char	48	1.0	ESP with 99.75% efficiency	48
5	Indsil Energy and Electro-chemicals Ltd.	Power, Coal fired	Coal	60	3.2	ESP	53

Table 4.1.4: Details of Representative Ferro Alloy Industries Selected for Stack Monitoring

Sr. No.	Name of Industry	Raw Material Used	Stack Height (m)	Stack Diameter (m)	Air Pollution Control Equipment	Particulate Matter Conc. (mg/Nm^3)
1.	Sarda Energy and Minerals Ltd.	Mn Ore + Coal + Coke + Dolomite + Quartz	40	1.8	FD cooler with Reverse Jet Bag Filter with 99.9% efficiency	48
2.	Indsil Energy and Electro-chemicals Ltd. – Stack 1	Mn Ore+ Coal + Coke + Dolomite + Quartz	30	0.8	4 bag Houses with 240 bags each, spark arrester before Bag House	--
3.	Indsil Energy and Electro-chemicals Ltd. – Stack 2	Mn Ore + Coal + Coke+ Dolomite + Quartz	30	0.8	2 bag Houses with 120 bags each, spark arrester before Bag House	81
4.	Raghuveer Ferro Alloy Pvt. Ltd.	Mn Ore + Coal + Coke + Dolomite + Quartz	30	0.8	Bag Filter	50

Table 4.1.5: Details of Representative Rolling Mills Selected for Stack Monitoring

Sr. No.	Name of Industry	Raw Material Used	Stack Height (m)	Stack Diameter (m)	Air Pollution Control Equipment	Particulate Matter Conc. (mg/Nm^3)
1.	Srinivasa Maruti Pvt. Ltd.	Coal for ingot melting	40	0.5	Gravitational Chamber+ Water Scrubber	--
2.	Shriram Steels Ltd.	Coal for ingot melting	75	0.6	Cyclone Scrubber	132
3.	Krishna Steels – Unit 1	Coal for ingot melting	60	0.5	Cyclone Scrubber	127
4.	Krishna Steels – Unit 2	Coal for ingot melting	60	0.5	Cyclone Scrubber	127

Sponge Iron Plants use iron ore, coal and dolomite/limestone as raw material in kiln. In sponge iron plants, stack height varies from 44 m to 70 m, whereas stack diameter varies between 2.4 m and 3.92 m. All the sponge iron plants have installed Electro-Static-Precipitator (ESP) with reduction efficiency more than 99%. Among the different parameters, only particulate matter is reported to be measured.

Captive Power Plants are associated with sponge iron industries, primarily to cater to the needs of the industry. Surplus power is sold to the State Electricity Board. Coal is the main fuel used in captive power plants with few plants using dolochar as well along with coal. Stack height varies from 42.5 m to 90 m and stack diameter varies from 1.0 to

3.9 m. All the power plants have installed Electro-Static-Precipitator (ESP) with particulate matter reduction efficiency more than 99%. Among the different parameters, only particulate matter is reported to be measured.

Ferro Alloy Plants use manganese ore, coal/coke, dolomite and quartz as raw materials. In Ferro alloy plants, stack height varies between 30 m and 40 m, whereas stack diameter varies between 0.8 m and 1.8 m. These plants have installed bag filters with particulate matter reduction efficiency more than 99%.

Steel Rolling Mills use coal in furnace for melting of ingots. In rolling mills, stack height varies from 40 m to 75 m, with small stack diameter of 0.5 m. Gravitational chamber or cyclone scrubber is used as particulate matter control device. In general, stack monitoring is not carried out in rolling mills.

4.2 Stack Emission Monitoring in Representative Industries

Stack monitoring was carried out at least once in each of the selected representative units during the study period in January-February, 2009 for particulate matter concentration (mg/Nm^3) determination. Stack gas parameters like velocity (m/s) and volumetric flow rate (Nm^3/hr) were calculated from Delta P (stack gas differential pressure) and stack gas temperature values recorded by the stack monitoring kit. Emission rate (kg/hr) was estimated by multiplying PM concentration (mg/Nm^3) and stack gas volumetric flow rate (Nm^3/hr).

Industry/Stack-wise summary of primary data on flue gas characteristics, viz. temperature, velocity, volumetric flow rate etc. along with concentration and emission load of particulate matter is presented in **Tables 4.2.1 to 4.2.4** respectively for sponge iron plants, captive power plants, ferro alloy units and rolling mills.

Table 4.2.1: Flue gas Characteristics with PM Concentration: Sponge Iron Plants

Sr. No.	Industry	Stack Temp. (°K)	Gas Velocity, (m/s)	Volumetric Flow Rate (Nm^3/h)	PM Conc. (mg/Nm^3)	PM Emission Rate (Kg/hr)
1.	Godavari Power and Ispat Ltd. – Stack 1	435	6.12	65,102	72	4.66
2.	Godavari Power and Ispat Ltd. - Stack 2	404	6.61	75,802	10	0.75
3.	Sarda Energy and Minerals Ltd. - Stack 1	407	6.91	2,09,673	30	6.34
4.	Sarda Energy and Minerals Ltd. - Stack 2	431	18.36	5,26,084	39	20.70
5.	PD Industries	441	8.81	1,45,454	56	8.18
6.	Rashmi Sponge Iron and Power Ind. Ltd.	383	4.74	1,32,507	146	19.40

Note: Stack PM emission standard for Sponge iron plant - 50 mg/Nm^3

In sponge iron plants, stack gas temperature varied from 383 K to 441 K, and flue gas velocity varied from 4.74 m/s to 8.81 m/s, except very high velocity (18.36 m/s) in one of the stack of Sarda Energy. PM concentration ranged between 10 mg/Nm^3 and 146 mg/Nm^3, and the corresponding PM emission rate was 0.75 to 20.7 kg/hr.

Table 4.2.2: Flue gas Characteristics with PM Concentration: Captive Power Plants

Sr. No.	Industry	Stack Temp. (°K)	Gas Velocity (m/s)	Volumetric Flow Rate (Nm^3/h)	PM Conc. (mg/Nm^3)	PM Emission Rate (Kg/hr)
1.	Godavari Power and Ispat Ltd.	417	6.25	58,357	122	7.12
2.	Sarda Energy and Minerals Ltd.- Stack 1	408	5.70	1,73,426	35	5.98
3.	Sarda Energy and Minerals Ltd. - Stack 2	381	9.84	2,26,063	31	7.0
4.	Rashmi Sponge Iron and Power Ind. Ltd.	378	4.21	8,955	48	0.43
5.	Indsil Energy and Electro-chemicals Ltd.	380	2.72	59,034	196	11.56

Note: Stack PM emission standard for Power plant - 50 mg/Nm^3

In power plants, stack gas temperature varied from 378 K to 417 K, and flue gas velocity varied from 2.72 m/s to 9.84 m/s. PM concentration ranged between 31 mg/Nm^3 and 196 mg/Nm^3, and the corresponding PM emission rate was about 6.0 kg/hr to 11.56 kg/hr, except for Rashmi Sponge Iron, wherein very low volumetric flow rate was observed, that resulted in extremely low PM emission rate (0.43 kg/hr).

Table 4.2.3: Flue gas Characteristics with PM Concentration: Ferro Alloy Plants

Sr. No.	Industry	Stack Temp. (°K)	Gas Velocity (m/s)	Volumetric Flow Rate (Nm^3/h)	PM Conc. (mg/Nm^3)	PM Emission Rate (Kg/hr)
1.	Indsil Energy and Electro-chemicals Ltd. – Stack 1	326	12.37	19,515	24	0.47
2.	Indsil Energy and Electro-chemicals Ltd. – Stack 2	328	11.33	17,760	3.4	0.061
3.	Raghuveer Ferro Alloy Pvt. Ltd.	331	10.18	15,813	115	1.82
4.	Sarda Energy and Minerals Ltd.	361	4.2	30,901	4.4	0.14

Note: Stack PM emission standard for Ferro Alloy plant - 50 mg/Nm^3

In Ferro alloy units, stack gas temperature was in narrow range of 326 K and 361 K, however, flue gas velocity varied from 4.2 m/s to 12.37 m/s. PM concentration ranged between 3.4 mg/Nm^3 and 115 mg/Nm^3. PM emission rate was very less, maximum being only 1.82 kg/hr. These units have relatively less stack diameter (about 0.8 m) and total volume of flue gas passing through the stacks is also very less.

Table 4.2.4: Flue gas Characteristics with PM Concentration: Rolling Mills

Sr. No.	Industry	Stack Temp. (°K)	Gas Velocity (m/s)	Volumetric Flow Rate (Nm^3/h)	PM Conc. (mg/Nm^3)	PM Emission Rate (Kg/hr)
1.	Shriram Steels Ltd.	318	2.49	2,269	28	0.06
2.	Krishna Steels - Stack 1	468	16.50	7,113	33	0.23
3.	Krishna Steels - Stack 2	423	3.63	1,728	201	0.34
4.	Srinivasa Maruti Pvt. Ltd.	520	10.57	4,086	2011	8.21

Note: Stack PM emission standard for Rolling mills - 150 mg/Nm^3

In Rolling Mills, stack gas temperature varied considerably from 318 K to 520 K, and flue gas velocity varied from 2.49 m/s to 16.5 m/s. Volumetric flow rate as well as PM concentration also varied considerably. PM concentration was recorded in the range of 28 to 2011 mg/Nm^3. Such a high concentration (2011 mg/Nm^3) is attributed to the non-functioning of pollution control device during the stack sampling period, thus resulting in extremely high PM concentration and hence PM emission rate.

Overall, there was wide variation in various parameters related to stack gas emissions e.g. stack gas differential pressure, temperature, velocity, volumetric flow rate among various types of industries, which was expected due to varied nature of process involved. However, variation in the similar type of industry could again be a function of various factors; viz. plant capacity, process conditions at the time of sampling, operational status of pollution control devices etc. A minor variation in any of the contributing factors may result in significant variations in measured parameters.

4.3 Chemical Characterization of Stack Particulate Matter

Particulate matter samples collected from the stack of different industries were subjected to chemical characterization with respect to cations, anions and heavy metals. The parameters determined are given in **Table 4.3.1**.

Table 4.3.1: List of Parameters Analyzed in Stack Particulate Matter

Cations	Sodium (Na^+), Potassium (K^+), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Ammonium (NH_4^+)
Anions	Sulfate (SO_4^{2-}), Nitrate (NO_3^-), Chloride (Cl^-), Fluoride (F^-)
Heavy Metals	Iron (Fe), Copper (Cu), Cadmium (Cd), Chromium (Cr), Zinc (Zn), Cobalt (Co), Nickel (Ni), Lead (Pb), Manganese (Mn)

Out of 19 particulate matter samples, 14 samples could be analyzed, as in the remaining 5 samples, either adequate quantity of dust was not available or the value was exceptionally high. The list of industries whose samples were further analyzed for chemical characterization along with particulate concentration is given in **Table 4.3.2.**

Table 4.3.2: Chemical Characterization and Particulate Matter Concentration in Stacks: Details of Industries

Sr. No.	Industry	Unit	Thimble	PM Conc. (mg/Nm^3)
	Sponge Iron Plants			
1.	Godavari Power and Ispat Ltd.	WHRB	1	72
2.	Sarda Energy and Minerals Ltd.	SIP, WHRB	4	35
3.	Sarda Energy and Minerals Ltd.	SIP, WHRB, Sister stack	5	30
4.	Sarda Energy and Minerals Ltd.	SIP, WHRB, Sister stack	6	39
5.	PD Industries	SIP, DRI process	11	56
6.	Rashmi Sponge Iron and Power Ind. Ltd.	SIP, DRI process	13	146
	Captive Power Plants			
7.	Sarda Energy and Minerals Ltd.	CPP Boiler	3	31
8.	Rashmi Sponge Iron and Power Ind. Ltd.	Power, FBC	12	48
9.	Indsil Energy and Electro-chemicals Ltd.	Power Coal fired	16	196
10.	Godavari Power and Ispat Ltd.	WHRB+AFBC	27	122
	Ferro Alloy Plants			
11.	Indsil Energy and Electro-chemicals Ltd.	Ferroy Alloy	14	24
12.	Raghuveer Ferro Alloy Pvt. Ltd.	Ferroy alloy	17	115
	Rolling Mills			
13.	Krishna Steels – Stack 1	Coal fired furnace, Ingot melting	9	33
14.	Krishna Steels – Stack 2		10	201

Industry and stack wise concentration of cations, anions and heavy metals in particulate matter samples is presented in **Tables 4.3.3 to 4.3.5**. Overall range and average concentration of each parameter for different category of industries is presented in **Table 4.3.6**.

Table 4.3.3: Concentration of Cations in Stack Particulate Matter Samples

Sr. No.	Industry	Cation Concentration, (mg/Nm^3)				
		Na^+	K^+	Ca^{2+}	Mg^{2+}	NH_4^+
	Sponge Iron Plants					
1.	Godavari Power and Ispat Ltd.	6.91	0.94	4.82	1.56	1.72
2.	Sarda Energy and Minerals Ltd.	6.59	0.07	0.59	0.69	0.00
3.	Sarda Energy and Minerals Ltd.	7.19	0.22	1.89	0.59	0.61
4.	Sarda Energy and Minerals Ltd.	11.27	0.35	2.60	1.39	0.00
5.	PD Industries	2.58	0.49	1.08	0.91	0.25
6.	Rashmi Sponge Iron and Power Ind. Ltd.	9.06	0.63	3.04	0.73	6.14
	Captive Power Plants					
7.	Sarda Energy and Minerals Ltd.	6.08	0.15	1.60	0.00	0.00
8.	Rashmi Sponge Iron and Power Ind. Ltd.	7.11	0.67	2.30	0.16	0.69
9.	Indsil Energy and Electro-chemicals Ltd.	15.28	1.21	5.67	0.59	0.68
10.	Godavari Power and Ispat Ltd.	11.94	0.45	17.42	0.62	0.23
	Ferro Alloy Plants					
11.	Indsil Energy and Electro-chemicals Ltd.	2.34	0.56	1.63	0.00	0.25
12.	Raghuveer Ferro Alloy Pvt. Ltd.	8.26	2.18	4.52	0.00	0.38
	Rolling Mills					
13.	Krishna Steels – Stack 1	5.22	0.36	2.37	0.39	1.15
14.	Krishna Steels – Stack 2	14.77	0.77	4.12	0.48	0.62

Table 4.3.4: Concentration of Anions in Stack Particulate Matter Samples

Sr. No.	Industry	Anion Concentration, (mg/Nm^3)			
		SO_4^{2-}	NO_3^-	Cl^-	F^-
	Sponge Iron Plants				
1.	Godavari Power and Ispat Ltd.	10.34	2.02	12.28	5.21
2.	Sarda Energy and Minerals Ltd.	5.07	0.54	3.46	1.36
3.	Sarda Energy and Minerals Ltd.	3.34	0.57	2.62	1.04
4.	Sarda Energy and Minerals Ltd.	3.84	1.21	5.08	0.89
5.	PD Industries	3.18	4.24	15.11	13.75
6.	Rashmi Sponge Iron and Power Ind. Ltd.	22.45	0.52	4.92	8.97
	Captive Power Plants				
7.	Sarda Energy and Minerals Ltd.	4.50	2.15	0.60	1.94
8.	Rashmi Sponge Iron and Power Ind. Ltd.	13.50	2.96	0.15	2.36
9.	Indsil Energy and Electro-chemicals Ltd.	34.88	18.99	3.16	13.55
10.	Godavari Power and Ispat Ltd.	10.52	1.08	12.13	7.29
	Ferro Alloy Plants				
11.	Indsil Energy and Electro-chemicals Ltd.	2.52	0.00	1.88	0.46
12.	Raghuveer Ferro Alloy Pvt. Ltd.	21.29	0.04	11.11	0.92
	Rolling Mills				
13.	Krishna Steels – Stack 1	2.28	4.86	2.00	1.07
14.	Krishna Steels – Stack 2	36.22	15.40	0.61	0.97

Table 4.3.5: Concentration of Heavy Metals in Stack Particulate Matter Samples

Sr. No.	Industry	Heavy Metal Concentration, (mg/Nm³)			
		Fe	Cu	Pb	Mn
	Sponge Iron Plants				
1.	Godavari Power and Ispat Ltd.	1.50	0.06	0.00	0.00
2.	Sarda Energy and Minerals Ltd.	0.77	0.00	0.00	0.01
3.	Sarda Energy and Minerals Ltd.	0.08	0.01	0.00	0.02
4.	Sarda Energy and Minerals Ltd.	0.07	0.01	0.00	0.00
5.	PD Industries	4.19	0.01	0.00	0.01
6.	Rashmi Sponge Iron and Power Ind. Ltd.	2.48	0.04	0.00	0.06
	Captive Power Plants				
7.	Sarda Energy and Minerals Ltd.	0.13	0.02	0.00	0.00
8.	Rashmi Sponge Iron and Power Ind. Ltd.	0.48	0.02	0.00	0.00
9.	Indsil Energy and Electro-chemicals Ltd.	1.43	0.02	0.00	0.06
10.	Godavari Power and Ispat Ltd.	3.52	0.01	0.00	0.03
	Ferro Alloy Plants				
11.	Indsil Energy and Electro-chemicals Ltd.	0.54	0.01	0.03	1.66
12.	Raghuveer Ferro Alloy Pvt. Ltd.	0.47	0.01	0.10	8.89
	Rolling Mills				
13.	Krishna Steels – Stack 1	0.15	0.02	0.02	0.00
14.	Krishna Steels – Stack 2	2.13	0.12	0.08	0.05

Table 4.3.6: Summary of Cations, Anions and Heavy Metals Concentrations (mg/Nm³) in Stack Particulate Matter Samples

Parameter	Sponge Iron		Captive Power Plant		Ferro Alloy		Rolling Mills	
	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
Cations								
Na^+	2.6-11.3	7.27	6.1-15.3	10.10	2.3-8.3	5.30	5.2-14.8	9.99
K^+	0.1-0.9	0.45	0.15-1.2	0.62	0.56-2.2	1.37	0.36-0.77	0.57
Ca^{2+}	0.6-4.8	2.34	1.6-17.4	6.75	1.6-4.5	3.07	2.4-4.1	3.24
Mg^{2+}	0.6-1.6	0.98	0.0-0.6	0.34	BDL	BDL	0.4-0.5	0.43
NH_4^+	0.0-6.1	1.45	0.0-0.7	0.40	0.25-0.38	0.32	0.6-1.2	0.89

Parameter	Sponge Iron		Captive Power Plant		Ferro Alloy		Rolling Mills	
	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
Anions								
SO_4^{2-}	3.2-22.4	8.04	4.5-34.9	15.85	2.5-21.3	11.91	2.3-36.2	19.25
NO_3^-	0 .5-4.2	1.52	1.1-19.0	6.30	0-0.04	0.02	3.9-15.4	10.13
Cl^-	2.6-15.1	7.25	0.15-12.1	4.01	1.9-11.1	6.50	0.6-2.0	1.31
F^-	0.9 -13.8	5.20	1.9-13.6	6.29	0.46-0.92	0.69	0.97-1.07	1.02
Heavy Metals								
Fe	0.1-4.2	1.52	0.13-3.5	1.39	0.47-0.54	0.50	0.15-2.13	1.14
Cu	0-0.6	0.02	0.01-0.02	0.02	0.01	0.01	0.0-0.12	0.07
Pb	BDL	BDL	BDL	BDL	0.03-0.10	0.06	0.02-0.08	0.05
Mn	0-0.06	0.02	0.0-0.06	0.02	1.7-8.9	5.28	0.0-0.05	0.03
PM Conc.	30-146	63	31-196	99	24-115	70	33-201	117

BDL – Below detectable limit

Among cations, concentration levels of sodium ions (Na^+) were found to be significant from all the four types of industries. The values of Na^+ ranged between 2.6 & 11.3 mg/Nm^3 in Sponge Iron Plants, between 6.1 & 15.3 mg/Nm^3 in Power Plants, 2.3 & 8.3 mg/Nm^3 in Ferro Alloy Plants and between 5.2 & 14.8 mg/Nm^3 in Rolling mills. Calcium ions (Ca^{2+}) were also found in all the industries. The maximum concentration of Ca^{2+} was found to be 4.8 mg/Nm^3 in Sponge Iron Plants, 17.4 mg/Nm^3 in Power Plants, 4.5 mg/Nm^3 in Ferro Alloy Plants and 4.1 mg/Nm^3 in Rolling mills.

Among anions, concentration levels of sulfate ions (SO_4^{2-}) were found to be significant from all the four types of industries. The values of SO_4^{2-} ions ranged between 3.2 & 22.4 mg/Nm^3 in Sponge Iron Plants, between 4.5 & 34.9 mg/Nm^3 in Power Plants, 2.5 & 21.3 mg/Nm^3 in Ferro Alloy Plants and between 2.3 & 36.2 mg/Nm^3 in Rolling mills. Nitrate ions (NO_3^-) were also found in all the industries in significant concentrations. The maximum concentration of NO_3^- was found to be 4.2 mg/Nm^3 in Sponge Iron Plants, 19.0 mg/Nm^3 in Power Plants, and 15.4 mg/Nm^3 in Rolling mills. Nitrate ions were not found in Ferro Alloy Plants. Concentration of Chloride ions was also found to be considerable in Sponge Iron, Power, and Ferro Alloy Plants, whereas Fluorides were found in Sponge Iron and Power Plants.

Among heavy metals, concentration levels of Iron (Fe) were found to be significant in Sponge Iron, Power Plant and Rolling Mills, whereas in Ferro Alloy Plants, concentration levels of manganese were significantly high. The results were as expected because of the specific input materials used in the respective industries. Concentration levels of Cu and Pb were found in traces, whereas other heavy metals (Cd, Cr, Zn, Co & Ni) were below detectable limits.

Industry-sector wise (Sponge Iron, Power, Ferro Alloy & Rolling mills), average concentrations of particulate matter in stack and their chemical characteristics in terms of cations (Na^+, K^+, Ca^{2+}, Mg^+ & NH_4^{2+}), anions (SO_4^{2-}, NO_3^-, Cl^- & F^-) and heavy metals (Fe, Cu, Pb & Mn) are depicted through **Figs.** 4.3.1 to 4.3.4, respectively

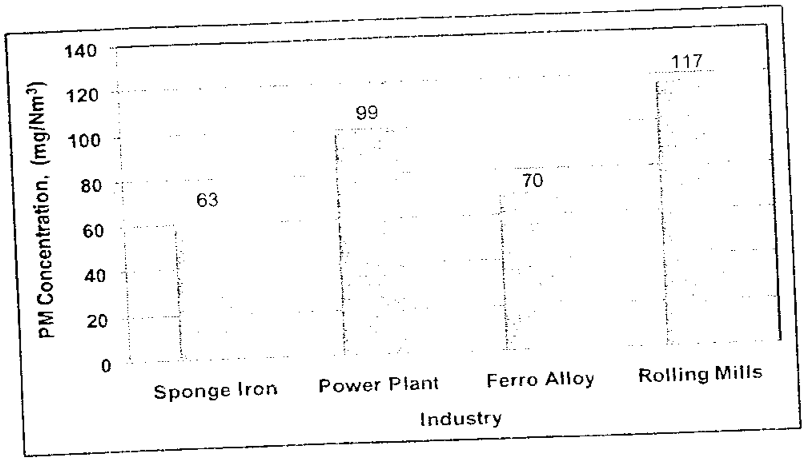


Fig. 4.3.1: Average Concentration of Particulate Matter in Stacks of Different Industrial Sectors

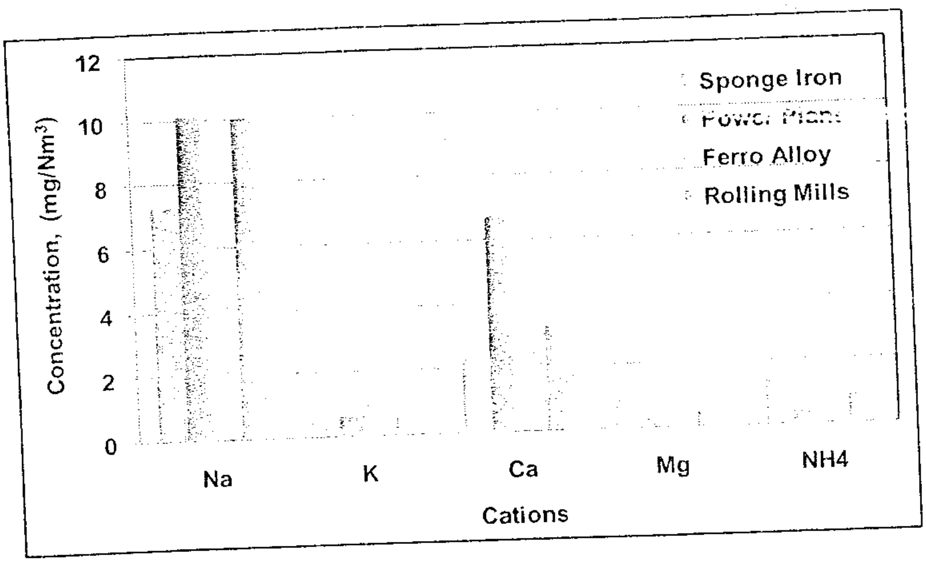


Fig. 4.3.2: Average Concentration of Cations in Stack Particulate Matter Samples of Different Industrial Sectors

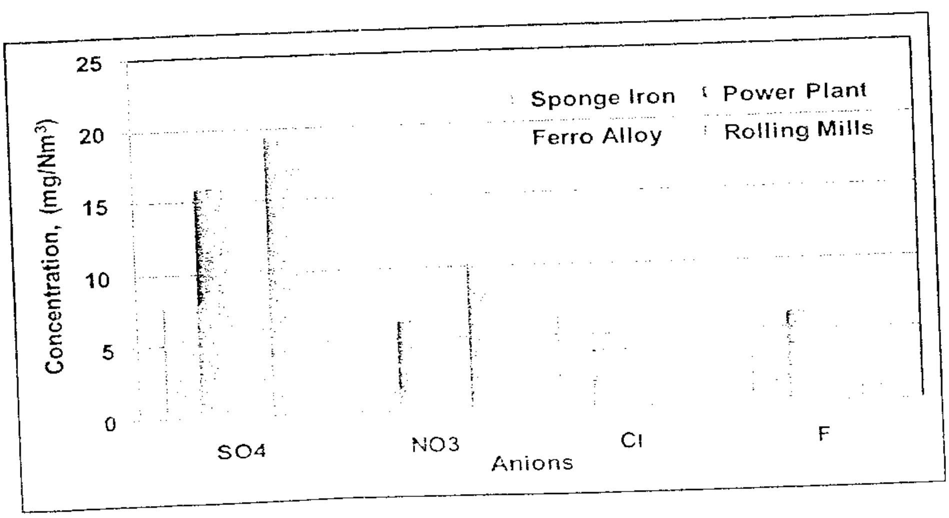


Fig. 4.3.3: Average Concentration of Anions in Stack Particulate Matter Samples of Different Industrial Sectors

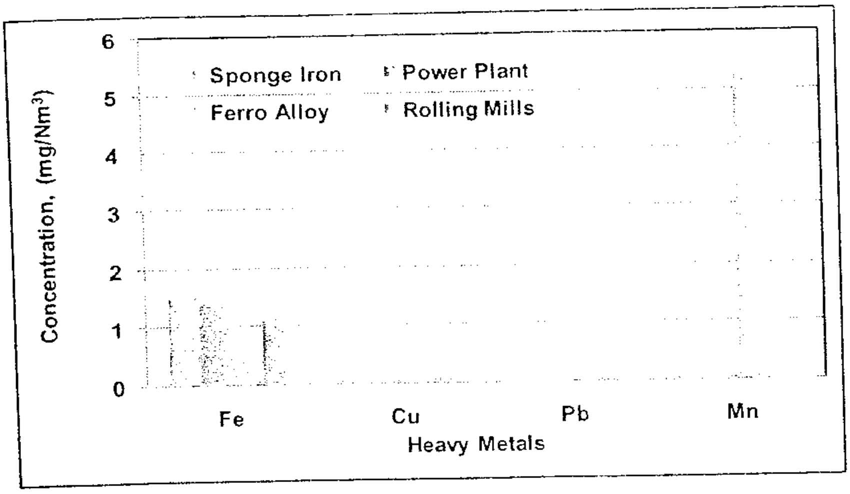


Fig. 4.3.4: Average Concentration of Heavy Metals in Stack Particulate Matter Samples of Different Industrial Sectors

From the above Figures (**4.3.1 to 4.3.4**), it is evident that particulate matter concentration is highest in Rolling mills, followed by Power Plant, Sponge Iron and Ferro Alloy Plants. Na^{+} are contributed by Power Plants and Rolling Mills, whereas K^{+} are contributed by Ferro Alloy Plants. Highest Ca^{2+} are emitted from Power Plants. Sponge Iron Plants contributed to Mg^{2+} and NH_4^{+}.

SO_4^{2-} are contributed by all the types of industries, highest being from Rolling mills. Similarly, NO_3^{-} are contributed by all the type of industries (except Ferro Alloy), highest being from Rolling mills. Sponge Iron Plants top in Cl^{-} ions, whereas Power Plants top in F^{-} contribution. Sponge Iron, Power Plants and Rolling Mills contributed Fe, whereas Ferro Alloy Plants emit Mn.

Summary of chemical characterization of PM samples in terms of Cations, Anions and Heavy metals collected from stacks in representative industries is presented in **Tables 4.3.7 and 4.3.8**.

Table 4.3.7: Average Concentration of Cations, Anions and Heavy metals in Stack PM Samples

Sampling Site	RSPM Conc. (mg/Nm^3)	Total Cations (mg/Nm^3)	Total Anions (mg/Nm^3)	Total Metals (mg/Nm^3)	Total Identified Mass (mg/Nm^3)
Sponge Iron	63	12.5	22.0	1.6	36.0
Power Plant	99	18.2	32.4	1.4	52.1
Ferro Alloy	70	10.1	19.1	5.9	35.0
Rolling Mills	117	15.1	31.7	1.3	48.1

Table 4.3.8: Percentage of Cations, Anions and Heavy metals in Stack PM Samples

Sampling Site	% Cations	% Anions	% Heavy Metals	% Identified Mass	% Unidentified Mass
Sponge Iron	19.8	34.9	2.5	57.1	42.9
Power Plant	18.3	32.7	1.4	52.4	47.6
Ferro Alloy	14.4	27.4	8.4	50.2	49.8
Rolling Mills	13.0	27.2	1.1	41.2	58.8
Overall Average	**16.0**	**31.0**	**3.0**	**50.0**	**50.0**

Of the total average PM concentration of 63 mg/Nm^3 in sponge iron plants, 99 mg/Nm^3 in power plants, 70 mg/Nm^3 in Ferro alloy plants and 117 mg/Nm^3 in rolling mills, the chemical constituents identified were 57.1%, 52.4%, 50.2% and 41.2% respectively. The remaining unidentified mass could be in the form of elemental carbon, organic carbon, silica and many other ions and metals. Further, based on the particulate matter concentrations and their chemical characterization, different industrial sectors have been ranked, as presented in **Table 4.3.9**.

Table 4.3.9: Ranking of Industrial Sector in terms of Stack Particulate Matter Chemical Characterization Parameters

Parameter	Ranking of Industry Sector			
	First	Second	Third	Fourth
PM Conc.	Rolling Mills	Power Plant	Ferro Alloy	Sponge Iron
Cations				
Na^+	Power Plant	Rolling Mills	Sponge Iron	Ferro Alloy
K^+	Ferro Alloy	Power Plant	Rolling Mills	Sponge Iron
Ca^{2+}	Power Plant	Rolling Mills	Ferro Alloy	Sponge Iron
Mg^{2+}	Sponge Iron	Power Plant	Rolling Mills	Ferro Alloy
NH_4^+	Sponge Iron	Rolling Mills	Power Plant	Ferro Alloy
Anions				
SO_4^{2-}	Rolling Mills	Power Plant	Ferro Alloy	Sponge Iron
NO_3^-	Rolling Mills	Power Plant	Sponge Iron	--
Cl^-	Sponge Iron	Ferro Alloy	Power Plant	Rolling Mills
F^-	Power Plant	Sponge Iron	Rolling Mills	Ferro Alloy
Metals				
Fe	Sponge Iron	Power Plant	Rolling Mills	Ferro Alloy
Mn	Ferro Alloy	--	--	--

It is pertinent to mention that average concentration (in mg/Nm^3) of particulate matter, SO_4^{2-} and NO_3^- are highest in Rolling Mills, whereas concentration of Na^+, Ca^{2+} & NH_4^+ are second highest in Rolling mills. Considering the volumetric flow rate of flue gases in Rolling Mills, total amount/emission load (in kg/hr or kg/day) from Rolling Mills could be much less as compared to Sponge Iron or Power Plants.

Chapter 5

Industrial Source Contribution Assessment

Chapter 5

Industrial Source Contribution Assessment

5.1 Emission Inventory of Industrial Sources

5.1.1 Estimation of Emission Load for PM & its Chemical Constituents

Particulate matter emissions released from different type of air polluting industries in Raipur region were calculated from the basic information (viz. stack diameter and flue gas velocity) provided by the industries. PM concentration measured by industries were not available for most of the industries; therefore, PM concentrations measured by the NEERI team in the representative industries were taken to estimate the total emission load from all stacks in various industrial sector, classified as Sponge Iron industries, Captive Power plants, Ferro alloy plants and Rolling mills.

Average characteristics of stack and flue gas along with measured average PM concentrations and estimated total PM emission load is presented in **Table 5.1.1**.

Table 5.1.1: Average Characteristic of Stacks and Flue Gas in Different Type of Industries

Industry Sector	No. of Stacks	Stack Dia, (m)	Flue Gas Temp. (°C)	Flue Gas Velocity, (m/s)	Volumetric Flow Rate, (Nm^3/hr)	Average PM Conc. (mg/Nm^3)	Total PM Emission Load, (kg/d)
Sponge Iron	48	2.1	140	8.5	76,436	63	5,547
Power Plant	18	2.6	138	8.6	1,19,122	99	5,095
Ferro Alloy	18	1.5	80	8.4	45,090	70	1,364
Rolling Mills	150	0.8	150	8.0	10,193	117	4,293

Among these industry sectors, highest PM emissions are estimated to be contributed by sponge iron plants (5,547 kg/d), followed by power plants (5,095 kg/d) and rolling mills (4,293 kg/d), whereas ferro alloy plants contribute only 1,364 kg/d PM emissions. The total emission load from all these sectors is estimated to be 16,299 kg/d. Similarly, total emission loads for iron and manganese are estimated to be about 257 kg/d and 106.7 kg/d respectively.

Further, total emission load of cations and anions contributed by the major industry sectors is also estimated considering the average concentration of these ions in the stack gas particulate matter samples. The estimated total daily emission load of cations and anions is presented in Table 5.1.2.

Table 5.1.2: Emission Load in Terms of Cations and Anions from Air Polluting Industries

Industry Sector	Cations Emission Load (Kg/d)					Anions Emission Load (Kg/d)			
	Na^+	K^+	Ca^{2+}	Mg^{2+}	NH_4^+	SO_4^{2-}	NO_3^-	Cl^-	F^-
Sponge Iron	640.2	39.6	206.0	86.3	127.7	708.0	133.8	638.4	457.9
Power Plant	519.8	31.9	347.4	17.5	20.6	815.7	324.2	206.4	323.7
Ferro Alloy	103.2	26.7	59.8	0.0	6.2	232.0	0.4	126.6	13.4
Rolling Mills	366.6	20.9	118.9	15.8	32.7	706.4	371.7	48.1	37.4
Total	**1629.7**	**119.1**	**732.1**	**119.6**	**187.2**	**2462.0**	**830.2**	**1019.4**	**832.4**

The total emission load of Na^+, K^+, Ca^{2+}, Mg^{2+} and NH_4^+ ions from all the major air polluting industries is estimated to be 1629.7 kg/d, 119.1 kg/d, 732.1 kg/d, 119.6 kg/d and 187.2 kg/d, respectively. The total emission load of SO_4^{2-}, NO_3^-, Cl^- and F^- is estimated to be 2462 kg/d, 830.2 kg/d, 1019.4 kg/d and 832.4 kg/d, respectively.

5.1.2 Emission Load based Contribution of Industrial Sectors

Percent contribution of different sector in terms of PM, Fe and Mn is shown in **Fig. 5.1.1**. Further, percent contribution of each industrial sector has also been estimated based on emission inventory of Cations and Anions as presented in **Figs. 5.1.2 and 5.1.3**, respectively.

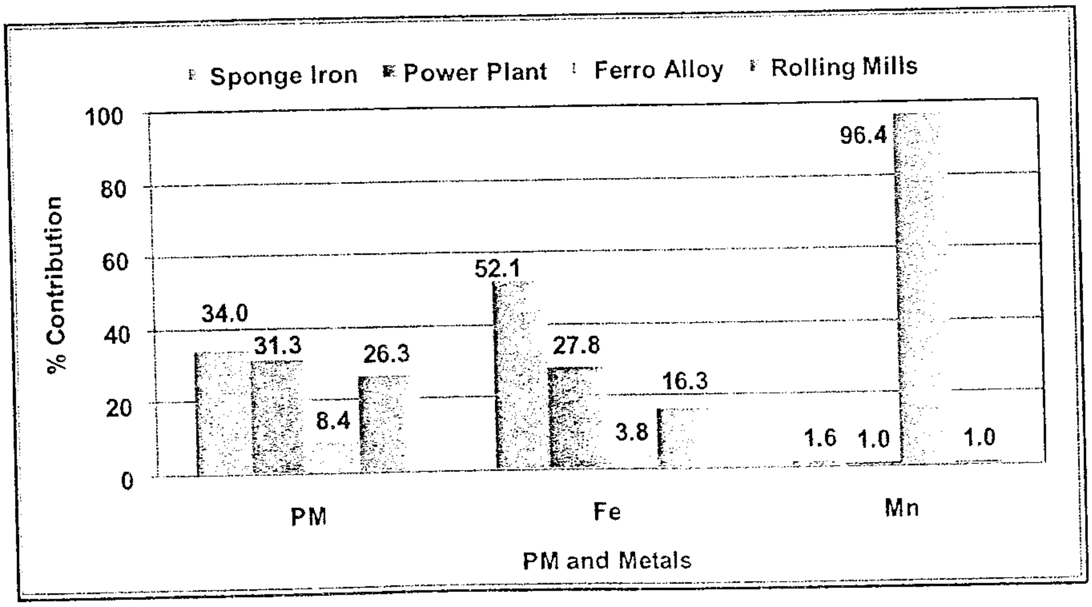


Fig. 5.1.1: Emission Load based Contribution of Industries: PM, Fe and Mn

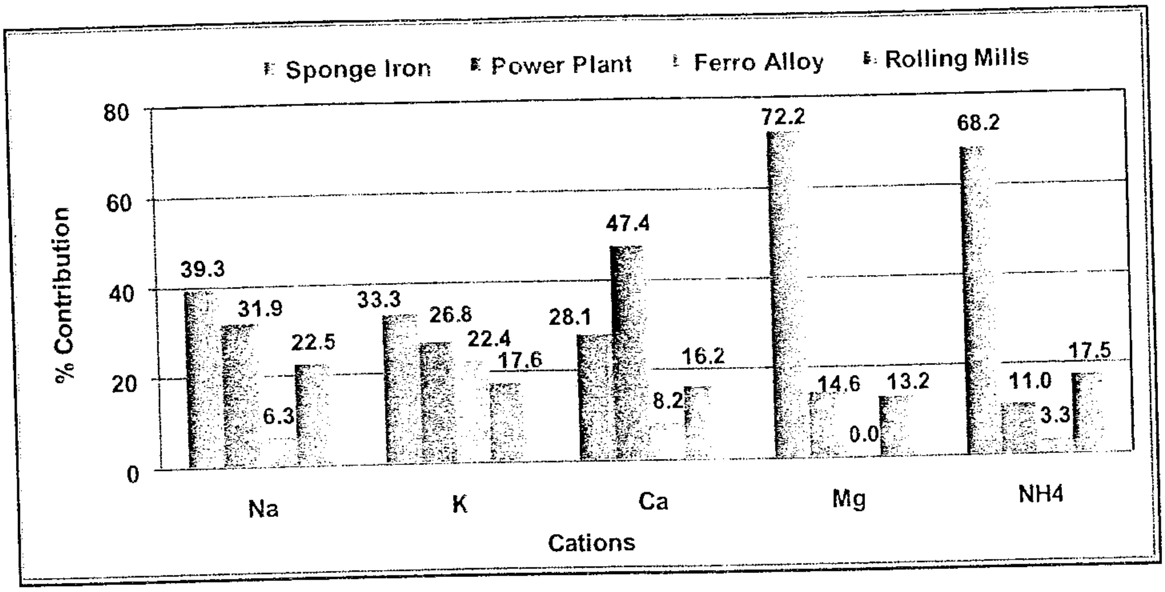


Fig. 5.1.2: Emission Load based Contribution of Industries: Cations

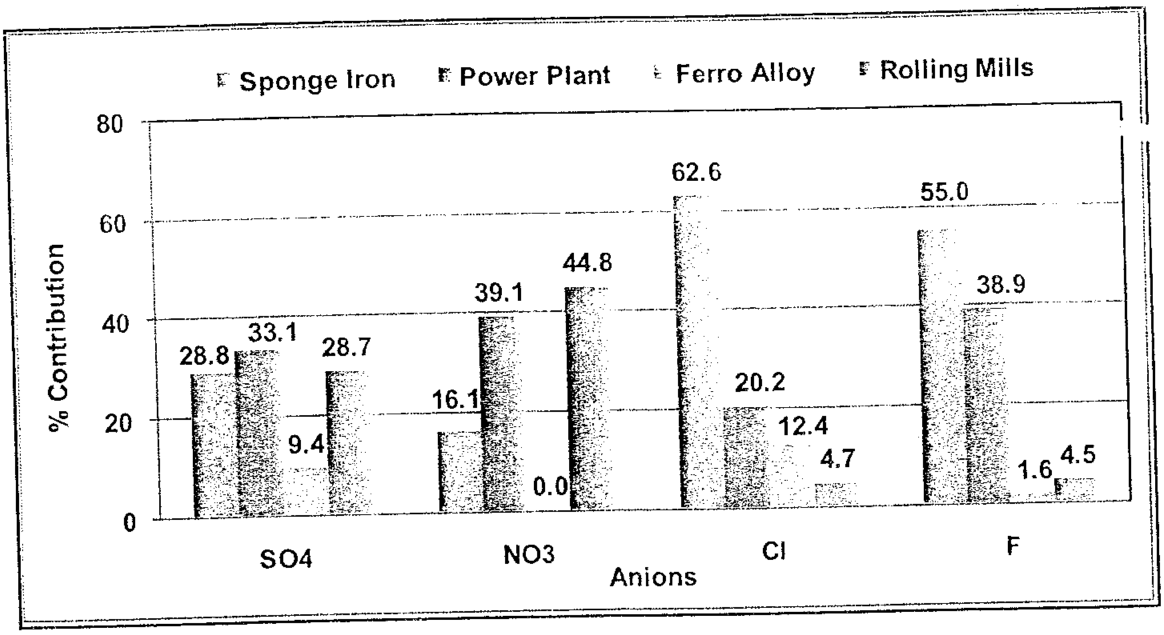


Fig. 5.1.3: Emission Load based Contribution of Industries: Anions

Perusal of **Figs. 5.1.1** indicates that among these four industry sectors, sponge iron industries contribute highest particulate matter (34.0%) and iron (52.1%), followed by power plants and rolling mills. Ferro alloy plants contribute as much as 96.4% of manganese, rest 3.6% is contributed by the sponge iron, power plants and rolling mills.

Perusal of **Figs. 5.1.2 & 5.1.3** shows that Sponge iron industries contribute highest percentage of Mg^{+}, NH_4^{+}, Na^{+} and K^{+}, whereas highest Ca^{2+} is contributed by power plants. In general, sponge iron and power plants account for 70-87% of different Cations in particulate matter. Similarly, Sponge iron industries also contribute significantly towards Chlorides, fluorides and sulfates. Power plants contribute mainly nitrates, sulfates and fluorides, whereas rolling mills contribute nitrates. Emissions from Ferro alloy stacks are found to be least.

Considering the total emission load of particulate matter (16.3 tons/day) from all the major air polluting industries, about 51% chemical constituents in terms of cations, anions and heavy metals have been identified. Based on emission inventory, the percentage wise content of different cations, anions and heavy metals is depicted in **Fig. 5.1.4**.

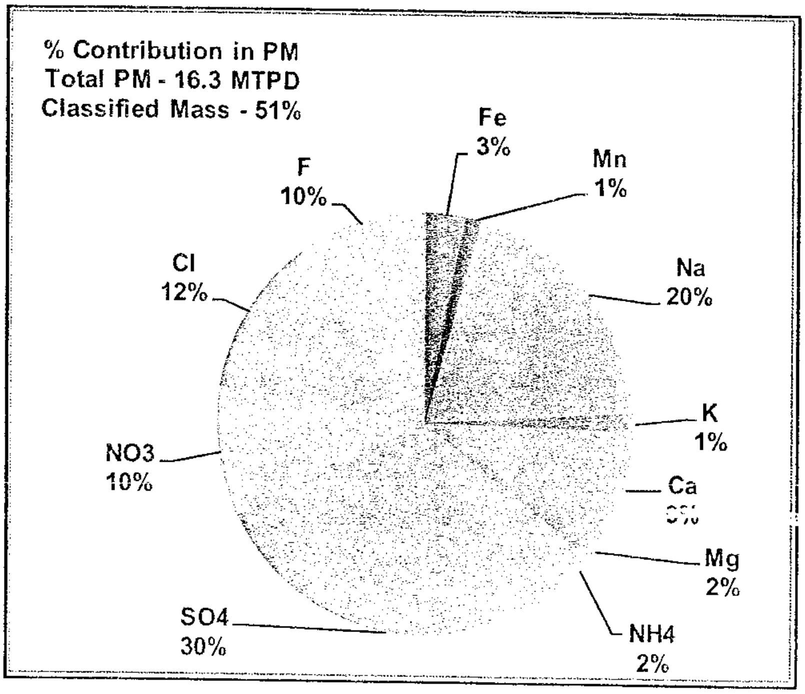


Fig. 5.1.4: Average % Chemical Constituents of Particulate Matter in Stack Samples

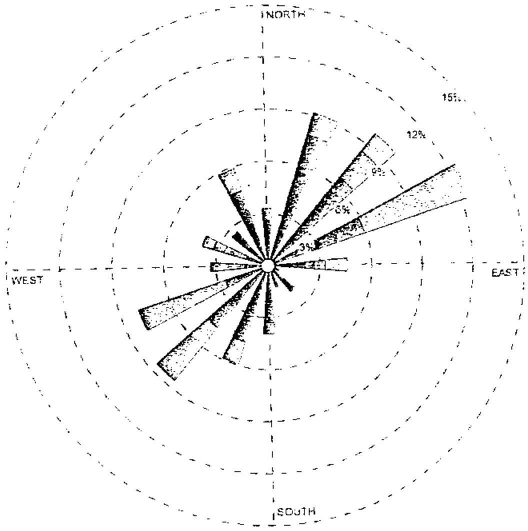
It is observed that total particulate matter emitted by industries contain 30% Sulfates, 20% Sodium, 12% Chlorides, 10% Fluorides, 10% Nitrates and 9% Calcium, whereas Iron is about 3% and other constituents contribute about 6%.

5.2 Meteorological Data of the Region

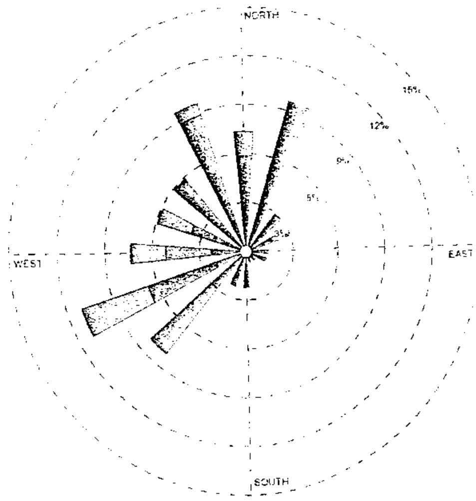
Surface meteorological parameters with respect to wind speed, wind direction, ambient temperature etc., were collected for the study region during the study period of February and March 2009. A meteorological station was set up at M/s Shri Bajrang Power and Ispat Ltd., which was considered as the centre of study region. All the meteorological parameters were monitored on hourly basis of the day.

5.2.1 8 and 24 Hourly Windrose Diagrams

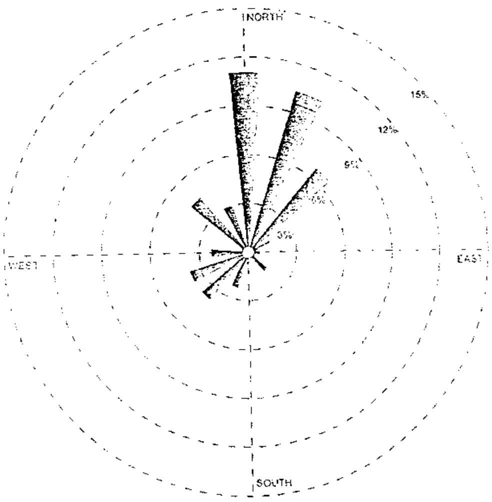
Wind speed and wind direction are represented through wind-rose diagrams. Wind rose diagrams have been prepared considering three 8 hourly averaging periods (06-14 hrs, 14-22 hrs and 22-06 hrs, similar to the air quality sampling period) and also for the 24 hourly average value for the month. All the hourly average values available for the whole month are averaged to prepare 8 and 24 hourly wind-rose diagrams. The wind-rose diagrams for the month of February 2009 and March 2009 are presented in **Fig. 5.2.1** and **Fig. 5.2.2**, respectively.



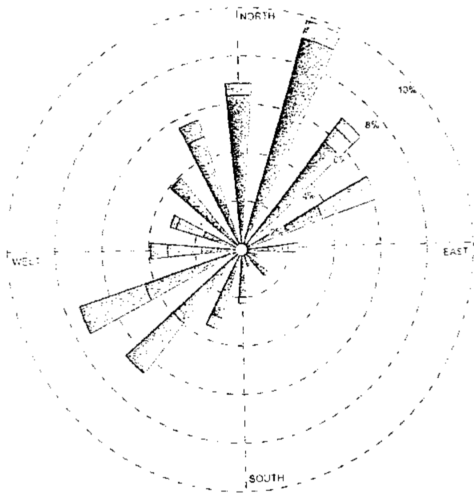
6-14 hrs, Feb 2009



14-22 hrs, Feb 2009



22-06 hrs, Feb 2009

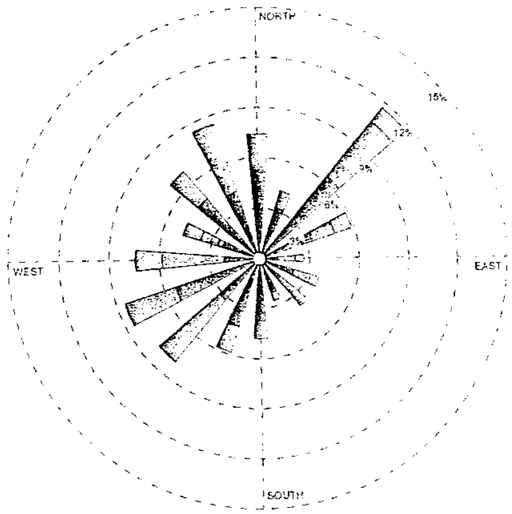


1-24 hrs, Feb 2009

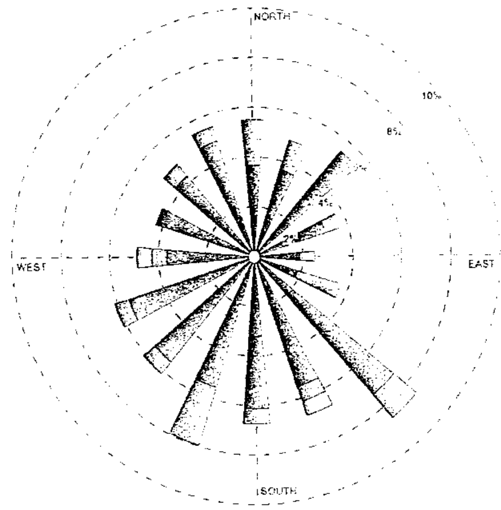
Legend: Wind Speed (m/s)

>= 3.0 | 2.0 - 3.0 | 1.0 - 2.0 | 0.5 - 1.0

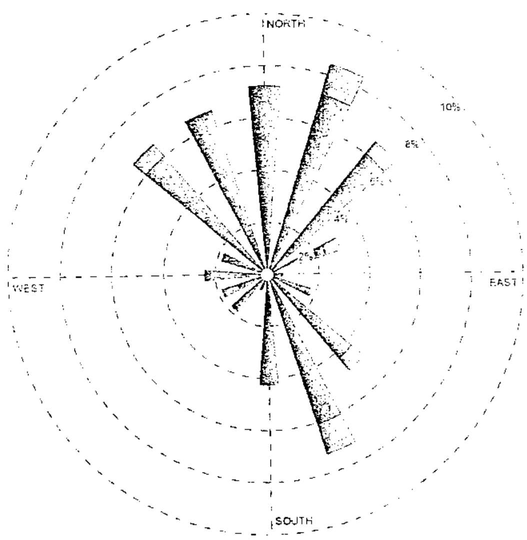
Fig. 5.2.1: 8 and 24 Hourly Wind rose Diagrams for Raipur Region: February 2009



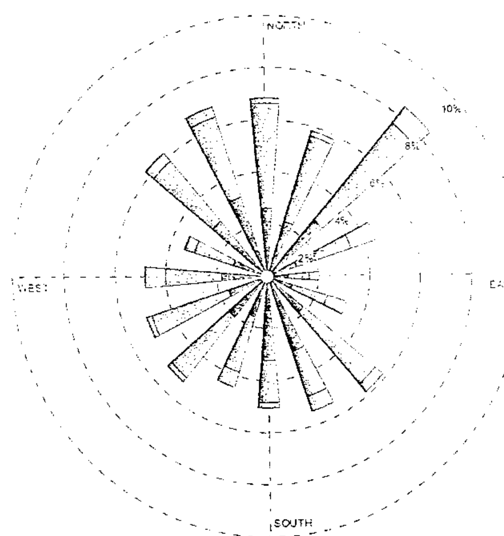
6-14 hrs, Mar 2009



14-22 hrs, Mar 2009



22-06 hrs, Mar 2009



1-24 hrs, Mar 2009

Legend: Wind Speed (m/s)

>= 3.0   2.0 - 3.0   1.0 - 2.0   0.5 - 1.0

Fig. 5.2.2: 8 and 24 Hourly Wind rose Diagrams for Raipur Region: March 2009

It is evident from the wind-rose diagrams that during February, wind blew from N-NE sector, whereas, during March, wind blew almost from all the directions, and also wind speed was higher during March as compared to the month of February.

Wind speed and wind direction data is further summarized for 8 hourly and 24 hourly averages. Occurrence of wind speed in different ranges (<0.5 m/s, 0.5-1.5 m/s, 1.5-2.5 m/s and 2.5-3.5 m/s), along with frequency distribution of wind direction for the month of February and March, is presented in **Table 5.2.1**.

Table 5.2.1: Analysis of Meteorological Data – Raipur Region (February-March 2009)

Month/ Averaging Period	Occurrence (%) of Wind Speed in the Range				Distribution of Wind & Predominant Directions with Percentage of Occurrence
	< 0.5 m/s (Calm)	0.5-1.5 (m/s)	1.5-2.5 (m/s)	2.5-3.5 (m/s)	
February 2009					
6-14 hrs	15.0	54.2	27.5	3.3	ENE (12.4%), NE (10%), NNE (9.2%), SW (8%), WSW (7%), SSW (6%), NNW (6%)
14-22 hrs	20.6	60.3	16.9	2.2	WSW (11%), NNW (10%), NNE (10%), N (8%), W (8%), NW (6%), WNW (6%)
22-06 hrs	48.5	50.8	0.7	-	N (11%), NNE (10%), NE (8%), WSW (4%), SW (4%)
1-24 hrs	28.7	54.9	14.5	2.0	NNE (10%), N (7%), NE (7%), WSW (7%), SW (6.5%), ENE (6%), NNW (5%),
March 2009					
6-14 hrs	3.7	54.5	35.4	6.3	NE (12%), WSW (8%), NNW (8%), WNW (7%), SW (8%), W (7%),
14-22 hrs	12.8	72.0	14.0	1.2	SE (9%), SSW (8%), S (7%), SSE (7%), SSW (6%), NW (5%), SW (6%), WSW (6%), N (5%), NNW (5%)
22-06 hrs	34.3	60.2	5.4	-	NNE (9%), SSE (7%), NW (7%), NNW (7%), NE (7%), SE (5%)
1-24 hrs	17.1	62.0	18.5	2.4	NE (9%), N (7%), NNW (7%), SE (6%), NW (6%), NNE (9%), SE (6%), W (5%), WSW (5%), SW (5%), SSE (5%),

It was observed that during February, calm conditions prevailed (wind speed less than 0.5 m/s) for 28.7% of the time, whereas in March calm conditions prevailed for lesser duration (17.1%), indicating that better dispersion conditions prevail during March as compared to the month of February.

It was further observed that more calm conditions prevail during night hours (22-06 hrs), whereas least during morning/day time (06-14 hrs). During day/evening hours, calm conditions were in between during both the months. During February, 54.9% of the time, wind speed was in the range of 0.5-1.5 m/s, whereas during March, 62% of the time, it was in this range. Only 2-2.4% of the time, wind speed was more than 2.5 m/s, indicating that meteorological conditions are not favorable for dispersion of pollutants. It may result in pollution accumulation leading to high concentration of pollutants in the region.

5.2.2 Hourly Variation in Meteorological Data

Hourly variation in wind speed and ambient temperature during the month of February and March 2009 is depicted in Figs. 5.2.3 and 5.2.4 respectively.

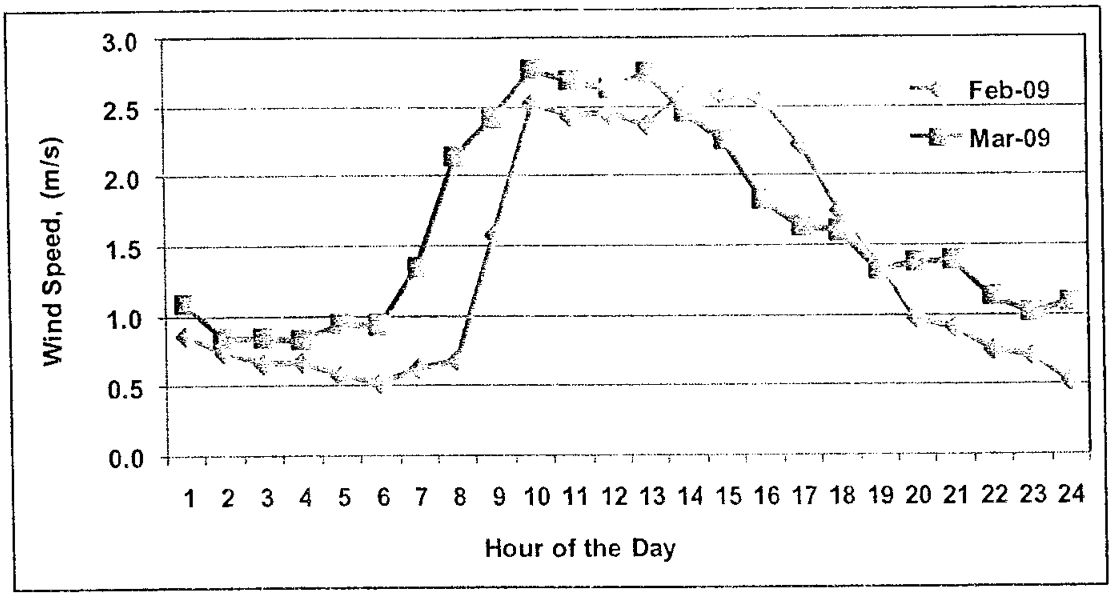


Fig. 5.2.3: Diurnal Variation in Wind Speed during February and March, 2009 in Raipur Region

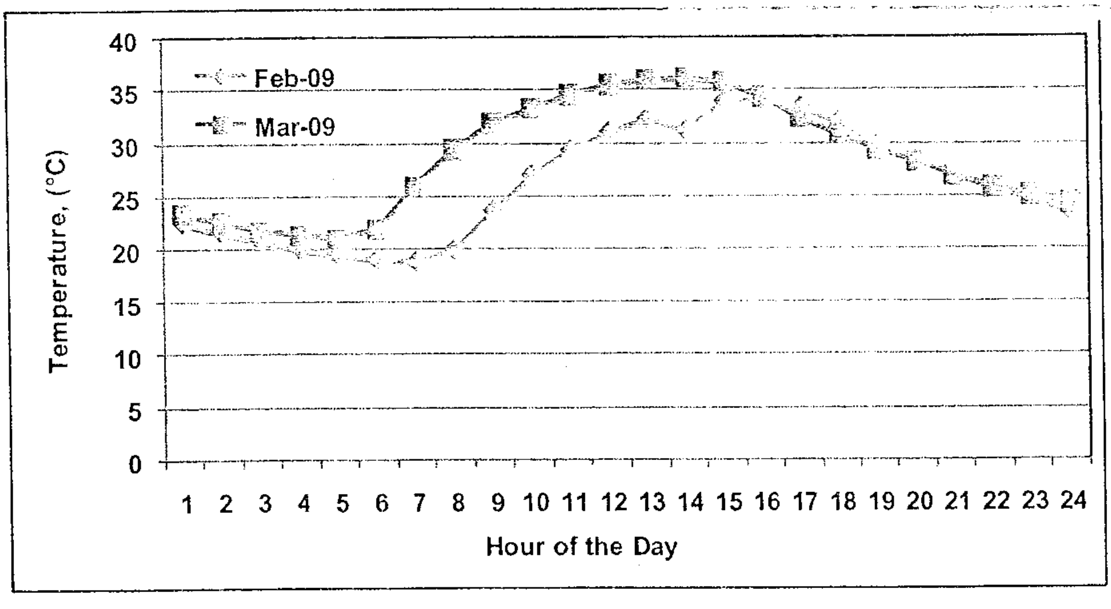


Fig. 5.2.4: Diurnal Variation in Ambient Air Temperature during February and March, 2009 in Raipur Region

It is clearly evident from **Fig. 5.2.3** that during February, from 8 pm till 8 am, wind speed is less than 1 m/s. During 9 am till 7 pm, wind speed is more than 1.0 m/s, maximum being 2.6 m/s at around 2 pm. During March, higher wind speed was observed from 7 am till 1 am in the night. Only during night hours (02-06 hrs), wind speed was less than 1.0 m/s.

Ambient air temperature during February was lowest at 6 am, which rose gradually, reached maximum at about 3 pm and then again started falling down gradually (**Fig. 5.2.4**). Similar kind of trend was observed in the month of March, however, daytime temperature during March was higher (by 5-10 °C) than in the month of February.

For modeling purpose, upper air meteorological data with respect to mixing height was taken from CPCB document and Pasquil-Gifford classification for stability class was taken. Meteorological data for stability classes as input to the model for the month of February and March is depicted in **Fig. 5.2.5**, and mixing height during winter season is presented in **Fig. 5.2.6**.

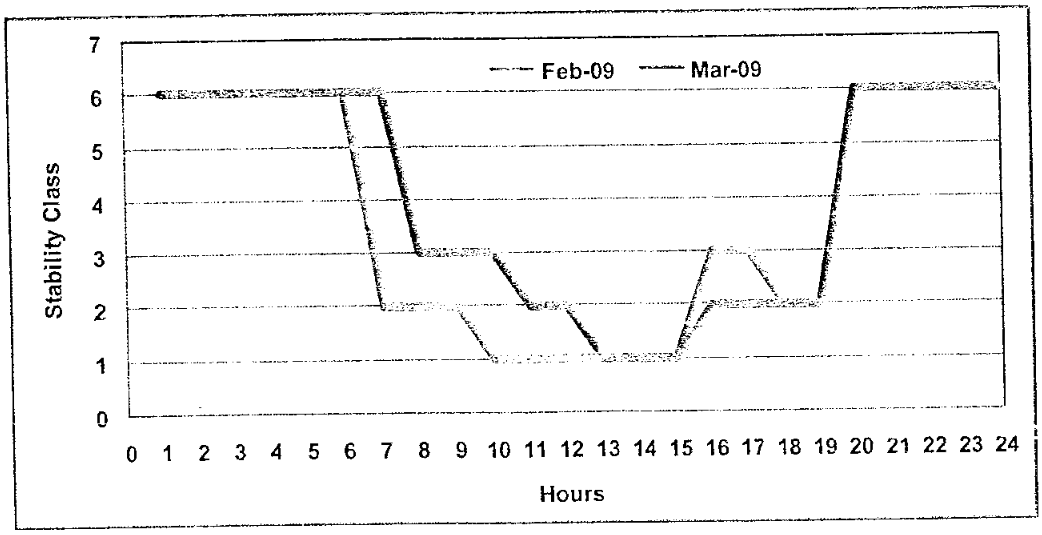


Fig. 5.2.5: Pasquill-Gifford Stability Classes: February & March 2009

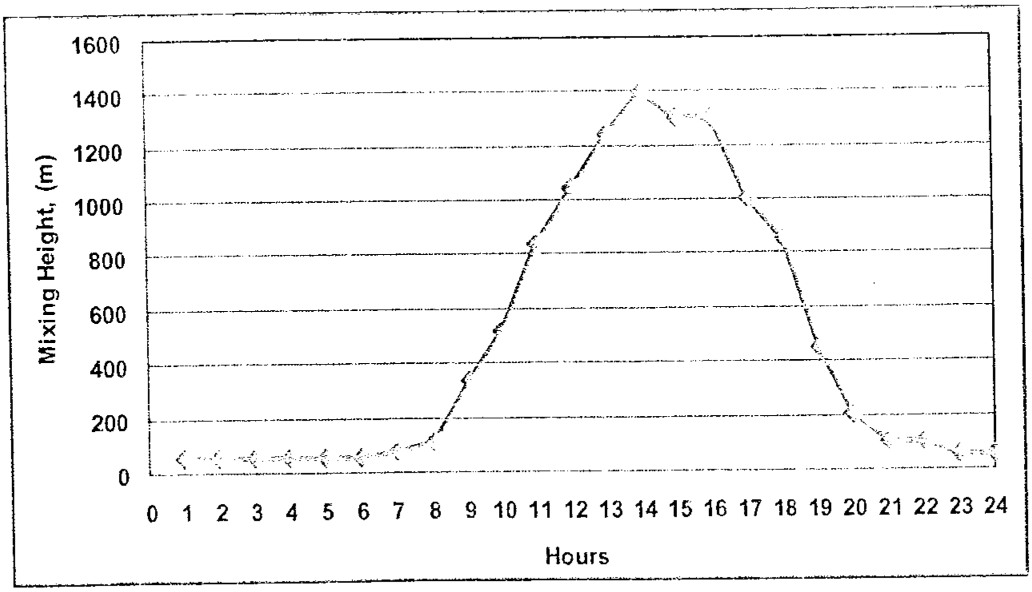


Fig. 5.2.6: Mixing Height for Raipur Region: Winter 2009

Stability class 6 persists during evening (6-7 pm onwards) till sunrise in the morning hours (6-7 am). Stability class 1 persists during 10-11 to 14-15 hrs. In winter season, mixing height starts building up after sunrise at about 7-8 am, reaching maxima at around 14-16 hours, and then it starts declining.

5.3 Air Quality Modeling

5.3.1 Methodology

In order to assess the cumulative impact of all the major industries (sponge iron, power plant, ferro alloy & rolling mills) on ambient air quality of Raipur region, air quality modeling has been carried out for two major parameters, i.e. Particulate matter and iron content in particulate matter.

Industrial Source Complex –Short Term (ISCST3) model has been used to predict the maximum ground level concentrations (GLCs) of these pollutants. The model requires data on stack characteristics with respect to stack diameter (m), flue gas velocity (m/s), coordinates of each stack (with respect to centre) and pollutant emission rate (g/s). Daily hourly meteorology data with respect to wind direction, wind speed (m/s), ambient temperature (K), stability class (1-6) and mixing height (m) is also required to study the transport/dispersion behaviors of plumes coming out of the tall stacks.

24 hourly average Ground Level Concentrations of pollutants (PM and Fe) were predicted in 20 km by 20 km area, with a grid size of 500 m x 500 m. It provided pollutant concentrations at 1600 receptor locations. Further, iso-concentration plots/ contours were drawn using Surfer graphical package.

Different emission and meteorological scenarios were considered in modeling exercises, as discussed here.

5.3.2 Emission Scenarios

Impact of industrial emissions with respect to particulate matter and its iron content has been predicted. Particulate matter emission rate was measured through actual monitoring in stacks of selected representative industries. In order to cover the wider range of possible emissions, three scenarios were considered.

Scenario 1: All the industries are emitting upper range of PM concentration (based on measured concentration in respective representative industries)

Scenario 2: All the industries are emitting average PM concentration (based on measured concentration in respective representative industries)

Scenario 3: All the industries are emitting PM concentration within the permissible level (Sponge iron, Power plant and Ferro alloy: 50 mg/Nm^3; Rolling mills - 150 mg/Nm^3)

Value of stack height, stack diameter and flue gas velocity is taken as provided by the respective industries. In case these values are not available for some industries, value of the similar kind of industry has been considered. Considering the above three scenarios, the total emission load for particulate matter for each industry sector has been estimated, as given in **Table 5.3.1**. Further, considering the Scenarios 1 and 2, total emission load for the major heavy metal, Iron (Fe) has been also estimated, and the same is given in **Table 5.3.2**.

Table 5.3.1: Industry Sector-wise PM Emission Load under Different Scenarios

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Maximum PM Conc. (mg/Nm^3)	Total PM Emission Load, (kg/day)	Average PM Conc. (mg/Nm^3)	Total PM Emission Load, (kg/day)	PM Conc. (mg/Nm^3) within Permissible Limit	Total PM Emission Load, (kg/day)
Sponge Iron	146	12,856	63	5,547	50	4,403
Power Plant	196	10,086	99	5,095	50	2,573
Ferro Alloy	115	2,240	70	1,364	50	974
Rolling Mills	201	7,376	117	4,293	150	5,504
Total		**32,558**		**16,299**		**13,454**

Table 5.3.2: Industry Sector-wise Fe Emission Load under Different Scenarios

Industry Sector	Scenario 1		Scenario 2	
	Maximum Fe Conc. (mg/Nm^3)	Total Fe Emission Load, (kg/day)	Average Fe Conc. (mg/Nm^3)	Total Fe Emission Load, (kg/day)
Sponge Iron	4.19	368.9	1.52	133.8
Power Plant	3.52	181.1	1.39	71.5
Ferro Alloy	0.54	10.5	0.50	9.7
Rolling Mills	2.13	78.2.3	1.14	41.8
Total		638.8		256.9

5.3.3 Model Results

Using the above three scenarios for particulate matter and two scenarios for Iron, model exercise was carried out using the meteorological data collected for the region during February and March 2009. Daily surface meteorological data recorded for month of February and March is considered in modeling, whereas upper air data for the season has been used. Model predicted first and the tenth highest GLCs (24 hourly average values) of particulate matter and iron content along with their occurrence during February and March are presented in **Tables 5.3.3 and 5.3.4**, respectively.

Table 5.3.3: Predicted First and Tenth Highest GLCs of PM along with their Occurrences under Different Emission and Meteorological Scenarios

Rank	Scenario 1			Scenario 2			Scenario 3		
	PM Conc. (µg/m^3)	X-Cord., (km)	Y-Cord., (km)	PM Conc. (µg/m^3)	X-Cord., (km)	Y-Cord., (km)	PM Conc. (µg/m^3)	X-Cord., (km)	Y-Cord., (km)
February 2009									
1st	39.3	7.0	5.0	20.3	7.0	5.0	19.9	4.0	-0.5
10th	38.7	6.0	3.0	19.9	7.0	4.0	19.0	4.5	-1.0
Average	**39.0**			**20.1**			**19.4**		
March 2009									
1st	30.6	7.0	5.0	16.4	4.0	-1.0	16.0	4.0	-1.0
10th	29.3	4.0	0.5	15.7	4.0	1.0	15.3	3.5	0.0
Average	**30.0**			**16.0**			**15.6**		

Table 5.3.4: Predicted First and Tenth Highest GLCs of Fe along with their Occurrences under Different Emission and Meteorological Scenarios

Rank	Scenario 1			Scenario 2		
	PM Conc. (μg/m³)	X-Cord., (km)	Y-Cord., (km)	PM Conc. (μg/m³)	X-Cord., (km)	Y-Cord., (km)
February 2009						
1st	0.7608	6.0	3.5	0.3096	6.0	3.5
10th	0.7351	6.5	3.0	0.3026	6.5	4.0
Average	**0.7480**			**0.3061**		
March 2009						
1st	0.5803	7.5	5.5	0.2360	7.0	5.0
10th	0.5527	6.5	5.0	0.2264	9.0	4.0
Average	**0.5665**			**0.2312**		

During February, average GLCs (average of first & 10th highest values) of particulate matter is predicted to be 39.0 μg/m³, 20.1 μg/m³ and 19.4 μg/m³ respectively under the Scenario 1, 2 and 3. These levels reduced correspondingly to 30.0 μg/m³, 16.0 μg/m³ and 15.6 μg/m³ for the meteorological conditions prevailing in the month of March. Similarly, average GLCs of Fe predicted under Scenario 1 and Scenario 2 reduced from 0.7480 μg/m³ to 0.5665 μg/m³ for met conditions of February month and from 0.3061 μg/m³ to 0.2312 μg/m³ for the month of March. This indicates better dilution/dispersion of pollutants during March as compared to February month. Summer months (April to June) may further provide better dilution/dispersion conditions, resulting in lower concentration levels of pollutants.

5.3.4 Iso-concentration Plots/Contours

Dispersion pattern and magnitude of pollutants, and the impact zone have been presented through iso-concentration plots, drawn under each emission and meteorological scenarios for particulate matter and iron. The iso-concentration plots are given through **Figs. 5.3.1 to 5.3.10**. Perusal of these figures indicate maximum impact zone lie in the North - East sector, which is mainly Siltara Industrial Area. The other impacted zone lies in South - East Sector, which is mainly Raipur city.

The range and interval values of iso-concentration plots for particulate matter and iron are summarized in **Table 5.3.5**, which shows lesser concentrations during March as compared to February. This indicates winter season would be critical season from air pollution point of view.

Table 5.3.5: Summary of Iso-concentration Plots of PM and Fe under Different Emission and Meteorological Scenarios

Parameter	Scenario 1		Scenario 2		Scenario 3	
	Range	Interval	Range	Interval	Range	Interval
PM Conc., (μg/m³)						
February 2009	15-35	10	10-20	5	10-15	5
March 2009	10-30	5	5-15	5	5-15	5
Fe Conc., (μg/m³)						
February 2009	0.2-0.6	0.2	0.1-0.3	0.1	--	--
March 2009	0.2-0.5	0.1	0.1-0.2	0.1	--	--

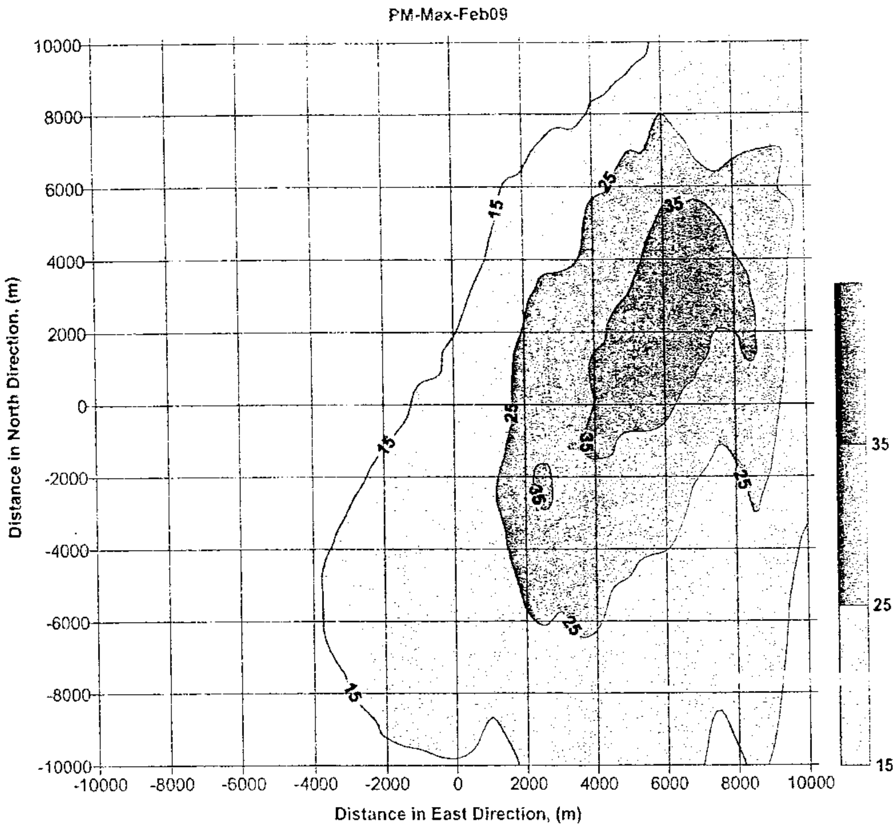


Fig. 5.3.1: Predicted Iso-concentration Plots for PM: Scenario 1 (February 2009)

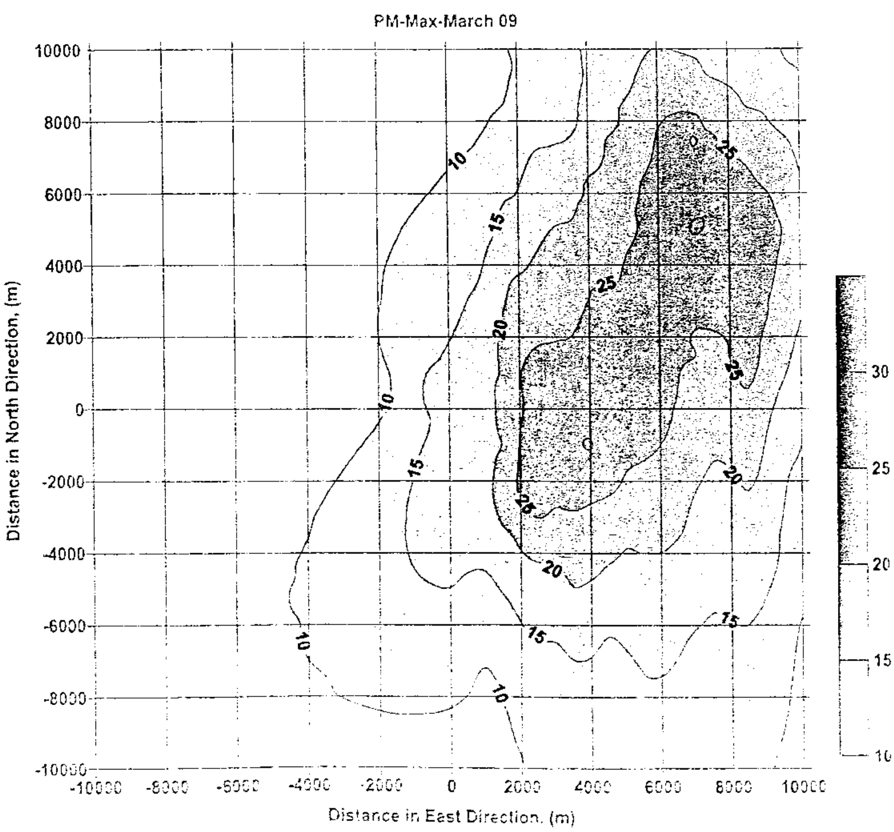


Fig. 5.3.2: Predicted Iso-concentration Plots for PM: Scenario 1 (March 2009)

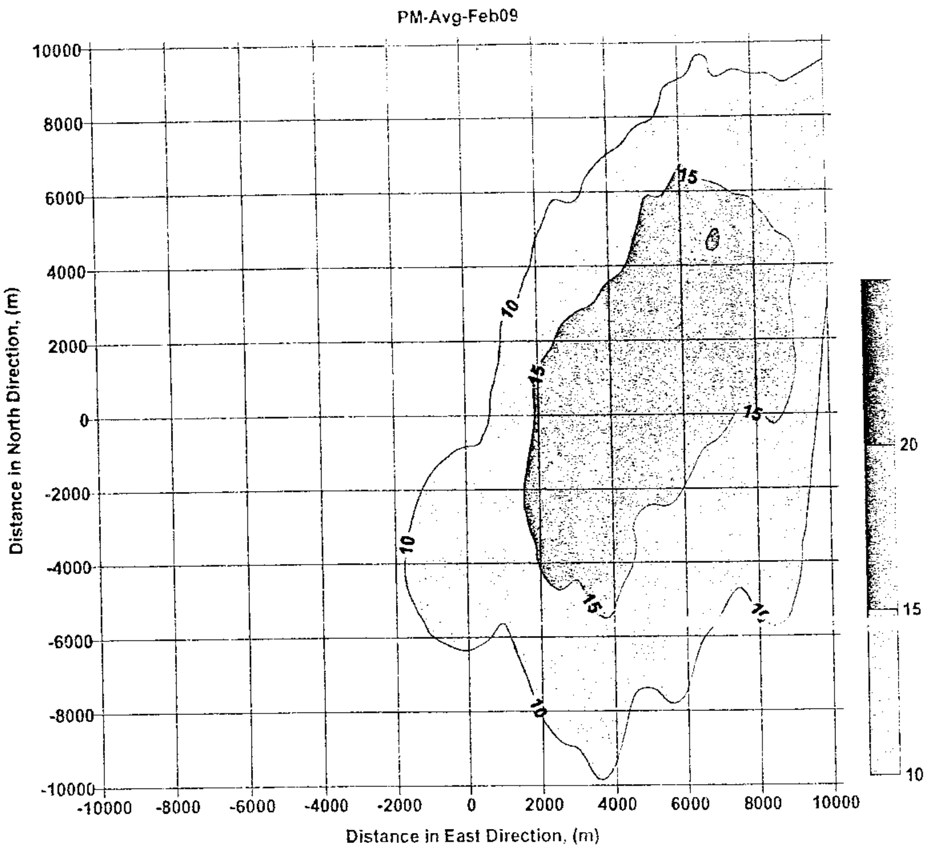


Fig. 5.3.3: Predicted Iso-concentration Plots for PM: Scenario 2 (February 2009)

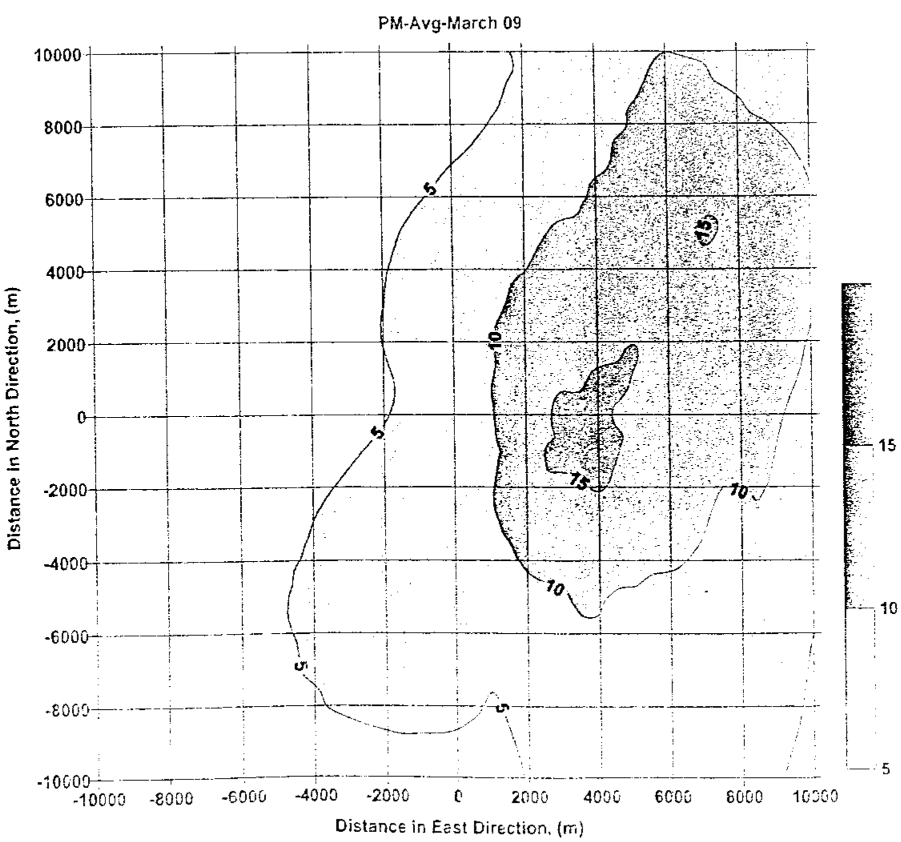


Fig. 5.3.4: Predicted Iso-concentration Plots for PM: Scenario 2 (March 2009)

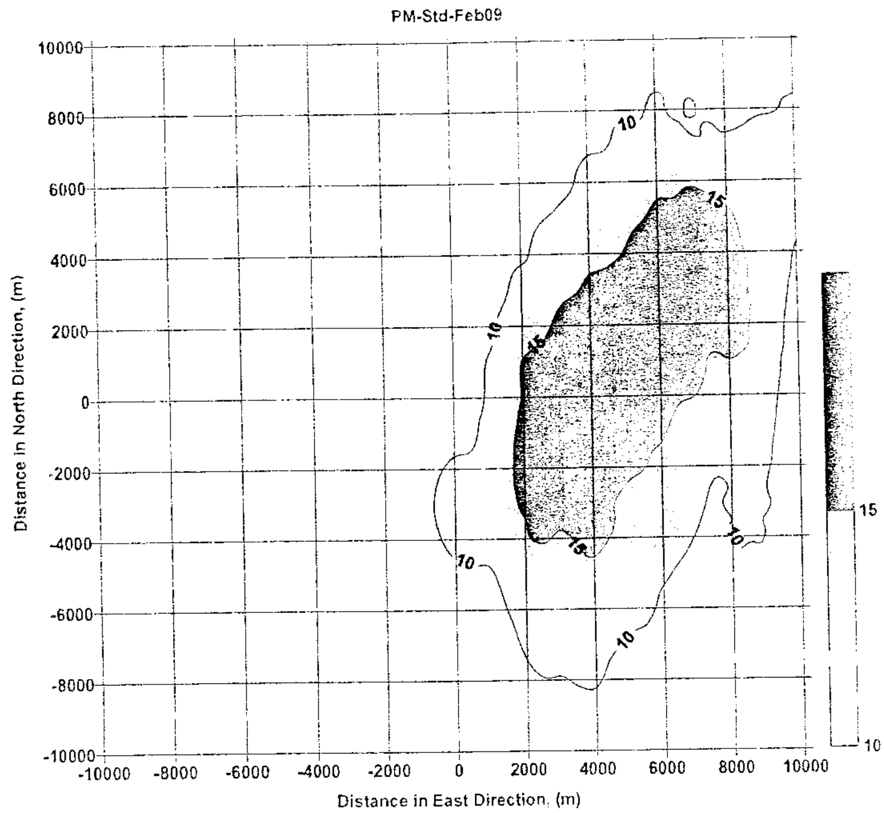


Fig. 5.3.5: Predicted Iso-concentration Plots for PM: Scenario 3 (February 2009)

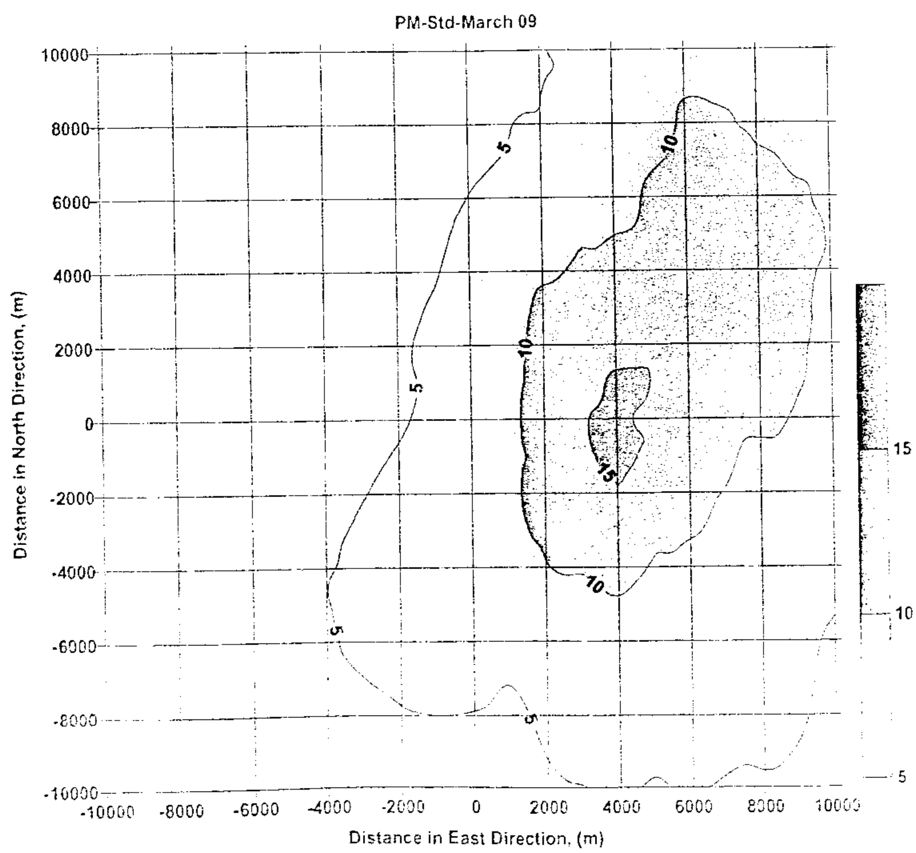


Fig. 5.3.6: Predicted Iso-concentration Plots for PM: Scenario 3 (March 2009)

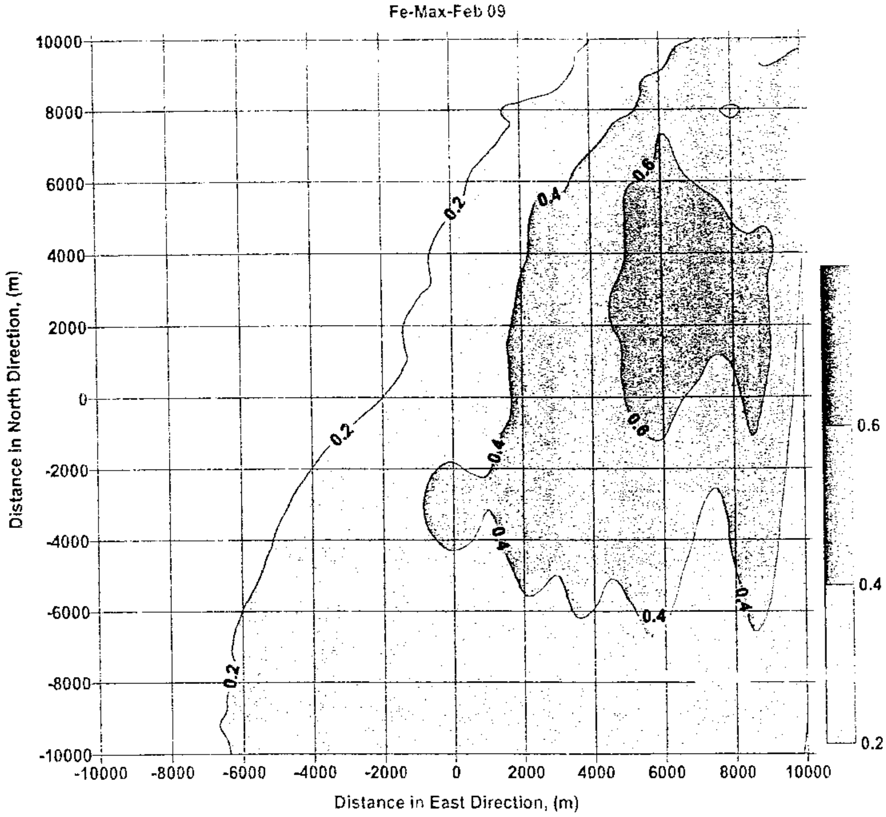


Fig. 5.3.7: Predicted Iso-concentration Plots for Iron (Fe): Scenario 1 (February 2009)

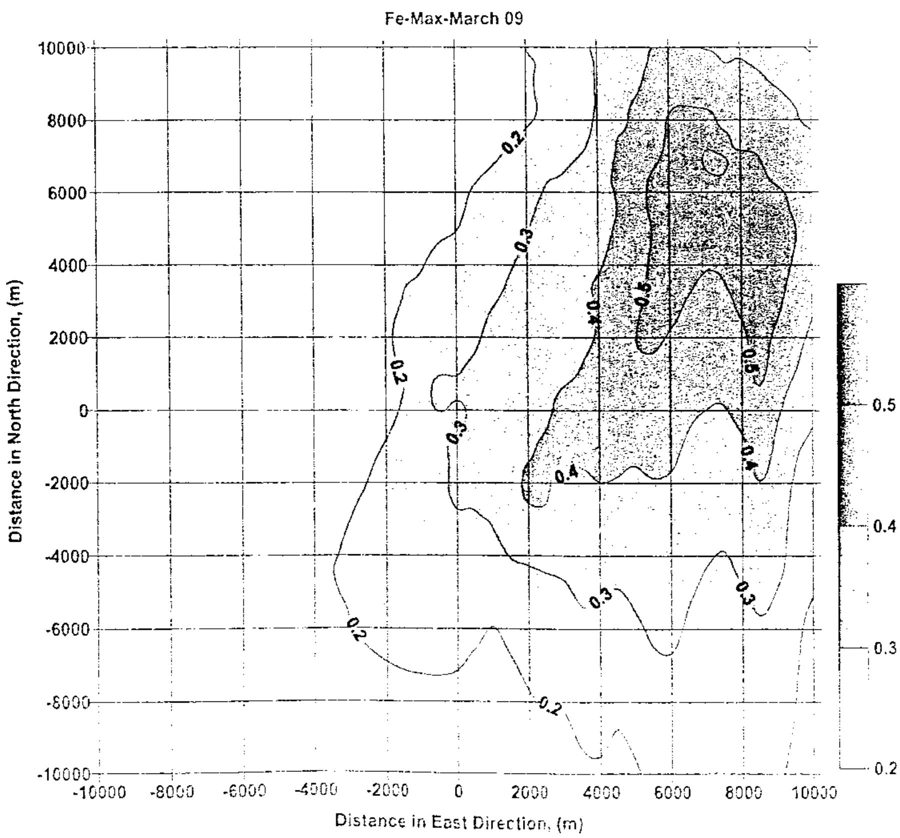


Fig. 5.3.8: Predicted Iso-concentration Plots for Iron (Fe): Scenario 1 (March 2009)

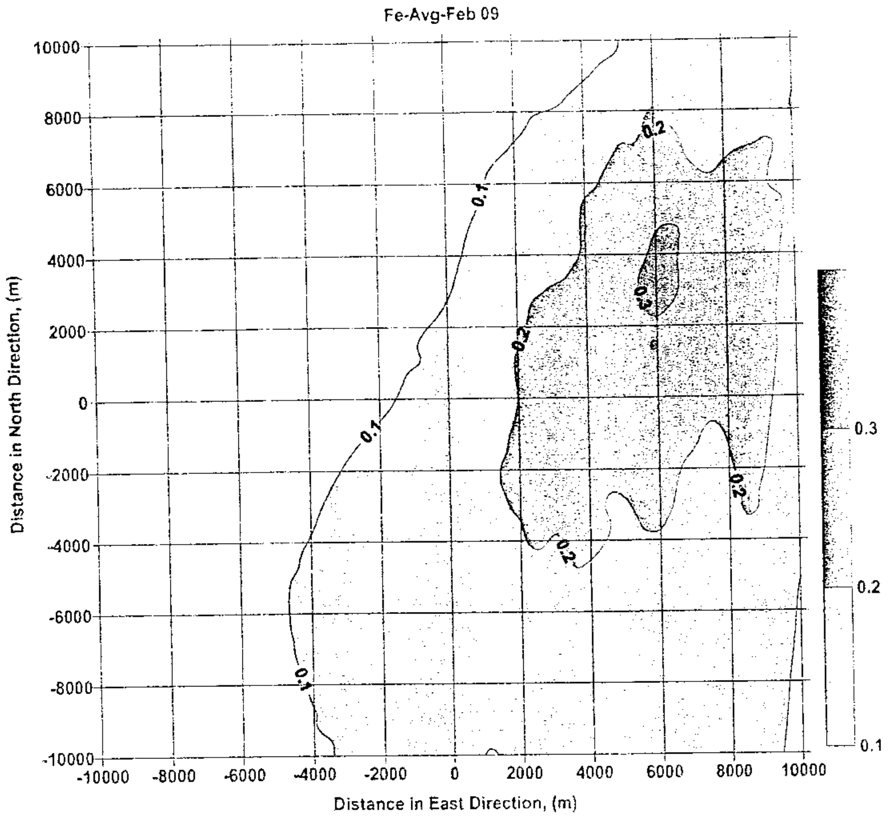


Fig. 5.3.9: Predicted Iso-concentration Plots for Iron (Fe): Scenario 2 (February 2009)

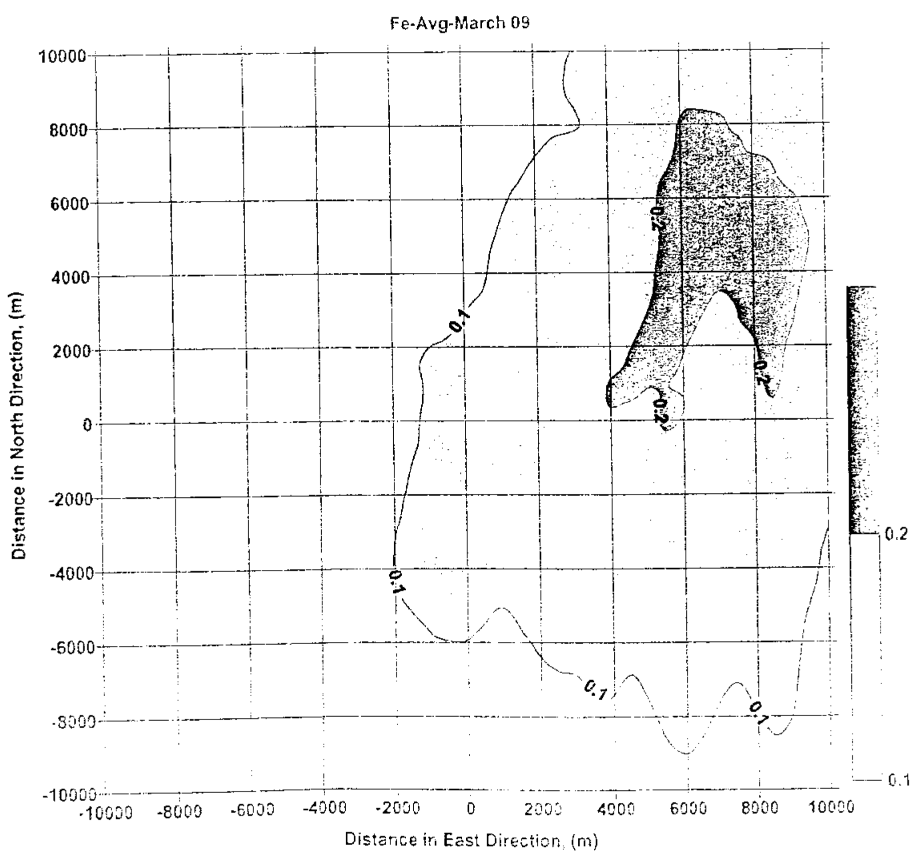


Fig. 5.3.10: Predicted Iso-concentration Plots for Iron (Fe): Scenario 2 (March 2009)

5.4 Contribution of Industrial Emissions to Ambient Air Quality

The contribution of four major air polluting industrial sectors, viz. sponge iron, power, ferro alloy and rolling mills, existing mainly in Siltarta & Urla industrial areas and their adjoining areas has been estimated on ambient air quality of the Raipur region through dispersion modeling. The model predicted results are compared with the actual measured concentration levels of particulate matter and its iron content at 8 monitoring locations. Model results are compared for first two emission scenarios and using the meteorological conditions prevailing during the month of February (representing winter season). Ratio of predicted concentration, representing contribution of industrial emissions at different monitoring locations is estimated. Predicted and measured concentration levels of particulate matter and iron at each of the monitoring location are presented in **Tables 5.4.1 and 5.4.2**, respectively.

Table 5.4.1: Comparison of Predicted and Measured Concentrations of Particulate Matter

Monitoring Site	Measured PM Conc., (µg/m³)	Predicted PM Conc., (µg/m³) under Scenario			% Ratio of Predicted to Measured Concentration under Scenario		
		1	2	3	1	2	3
Urban Sites							
Jai Stambh Chowk	184	16.5	8.5	8.1	9.0	4.6	4.4
Khamtarai	187	24.8	13.1	12.9	13.3	7.0	6.9
Kabirnagar	435	17.0	9.0	8.9	3.9	2.1	2.0
Telecom Colony	274	18.7	9.2	7.8	6.8	3.4	2.8
Rural Sites							
Dhaneli	234	29.2	14.4	12.5	12.5	6.2	5.3
Sondra	312	25.4	12.5	11.1	8.1	4.0	3.6
Kumhari	135	12.7	6.6	6.0	9.4	4.9	4.4
Dharsiwa	136	8.1	4.0	3.4	6.0	2.9	2.5
Average of all Sites	**237**	**19.1**	**9.7**	**8.8**	**8.0**	**4.1**	**3.7**

Table 5.4.2: Comparison of Predicted and Measured Concentrations of Iron in PM

Monitoring Site	Measured Fe Conc., (µg/m³)	Predicted Fe Conc., (µg/m³)		% Ratio of Predicted to Measured Concentration	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
Urban Sites					
Jai Stambh Chowk	3.685	0.2901	0.1226	7.9	3.3
Khamtarai	3.600	0.3955	0.1735	11.0	4.8
Kabirnagar	17.42	0.2764	0.1206	1.6	0.7
Telecom Colony	5.455	0.3899	0.1542	7.1	2.8
Rural Sites					
Dhaneli	7.050	0.6007	0.2404	8.5	3.4
Sondra	13.315	0.5294	0.2108	4.0	1.6
Kumhari	3.840	0.2284	0.0955	5.9	2.5
Dharsiwa	5.255	0.1639	0.0657	3.1	1.3
Average of all Sites	7.450	0.3590	0.1480	6.6	2.7

It has been observed that measured RSPM concentrations at Urban sites range between 184 µg/m^3 and 435 µg/m^3, whereas at Rural sites it varies between 135 µg/m^{3}and 312 µg/m^3, with an overall average of 237 µg/m^3 in the Raipur region. PM concentration predicted under Scenarios 1, 2 and 3 are found to be much less than the measured concentrations. Percent ratios of predicted concentration to the measured concentrations are found to be in the range of 3.9% to 13.3% at Urban sites and 6.0-12.9% at Rural sites. Overall average percent ration is found to be 8.0% under Scenario 1, 4.1% under Scenario 2 and 3.7% under Scenario 3.

Based on model results for Fe content in particulate matter, the overall average contribution of industrial emissions is found to be only 6.6% under Scenario1 and 2.7% under Scenario 2.

In summary, predicted concentrations at all the sites are found to be much less as compared to the measured concentration levels of particulate matter under the given conditions and assumptions considered in the study. This may be attributed to several other factors as discussed here.

5.5 Identified Sources of Air Pollution in Raipur Region

From the analysis of predicted and measured concentration levels of particulate matter and its chemical characterization in the present study, it has been estimated that the contribution of particulate matter from the stacks of major air polluting industries to the ambient air quality (in terms of particulate matter) is of the order of 19% (vary at different locations). It is pertinent to mention that the estimated contribution of industrial emissions to the ambient air quality of Raipur region is subjected to the numerous variations/ uncertainties associated with various factors, conditions, assumptions and limitations of the various sources of air pollution present in the study region. Some of these are:

- Estimation of contribution of industrial emissions includes only major air polluting industries (sponge iron, captive power, ferro alloy and rolling mills). Activities and processes involved in large number of small and medium scale industries existing in the region may also contribute significant particulate matter pollution.

- Particulate matter emissions emitted through stacks of these industries are accounted for, however, fugitive emissions arising due to transport & handling of various input materials and finished products, solid waste (bottom ash, fly ash etc.), re-suspension of dust due to movement of trucks in the industries is observed to be one of the major sources of particulate matter pollution in the region.

- Stack emission monitoring was carried out only in representative process stacks in selected industries; therefore the estimated emissions are representative only and may vary considerably depending upon the process and operating conditions of each of the industries. This will result in varied amount of particulate matter emissions along with volumetric flow rate of gas and its temperature from each of the stack, thereby affecting the predicted GLCs.

- A large number of heavy duty vehicles (loaded & unloaded trucks) ply in the region. These vehicles (trucks and other commercial vehicles) catering to the needs of industries and also transporting material to other cities, become another major source of air pollution, mainly particulate matter, sulfur di-oxide, nitrogen di-oxide, carbon mono-oxide, hydrocarbons etc. It has been observed that at many places, movement of these vehicles results in re-suspension of road dust in huge amount. Also sometimes material loaded in the vehicles keeps spilling during movement.

- All the roads in the region are yet to be made pucca (tarred/cemented), which due to movement of vehicles/ high speed wind often become source of particulate pollution.

- It has also been observed that solid waste from different industries is dumped in low lying area or is being used for different purposes; however, in the absence of proper care, it also leads to generation of air pollution.

- The study region covers a lot of rural/village area, wherein agriculture related activities are performed, resulting in particulate matter pollution. Further, different types of fuels like wood/dung cake, coal etc are used in village houses resulting to various air pollutants.

- The whole region has alluvial soil, which has less moisture content. Such soil gets easily carried away in the atmosphere with speedy wind or due to movement of vehicles, and become another major source of particulate matter pollution.

Air quality monitoring site-wise predicted contribution of industrial sectors and other possible other sources influencing air quality in terms of particulate matter are summarized in **Table 5.6.1**.

Table 5.6.1: Site-wise Predicted % Contribution of Industrial Sectors (in terms of Particulate Matter under Scenario 1) and Identified Other Sources of Air Pollution

Monitoring Site	Measured PM Conc., (μg/m^3)	Predicted Maximum Contribution of Industrial Sectors, (%)	Other Sources of Air Pollution
Urban Sites			
Jai Stambh Chowk	184	9.0	Commercial activities, fuel combustion in hotels & restaurants, residential areas, high intensity traffic (mainly 2, 3 & 4 wheelers)
Khamtarai	187	13.3	Residential colonies including slum areas, proximity to saw mills, railway line, use of low quality fuels like coal balls
Kabirnagar	435	3.9	Recently developed residential area, construction activities, loose soil/road dust, proximity to NH6, high intensity heavy duty traffic
Telecom Colony	274	6.8	Mainly residential area with congested colonies, limited commercial and traffic activities
Rural Sites			
Dhaneli (near Siltara Industrial area – Phase I)	234	12.5	Rural area setting, proximity to agricultural fields/activities and national highway with high intensity heavy duty traffic, poor condition of roads, lifting of road dust
Sondra (near Siltara Industrial area – Phase II)	312	8.1	Rural area setting, proximity to agricultural fields/activities and large industries with low intensity traffic, poor condition of roads, lifting of road dust
Kumhari	135	9.4	Rural area setting, proximity to agricultural fields/activities, earthen pots making and baking with locally available fuels, brick kiln, poor condition of roads, lifting of road dust
Dharsiwa	136	6.0	Rural area setting, proximity to agricultural fields/activities and national highway with high intensity heavy duty traffic, poor condition of roads, lifting of road dust

In order to minimize the problem of air pollution caused by various sources of air pollution, a multi-sectoral approach involving different stakeholders needs to be adopted in the Raipur region. The air pollution control/mitigation strategies and management plans leading to improvement in air quality of Raipur region are delineated in the next Chapter.

Chapter 6

Strategy for Air Quality Management

Chapter 6

Strategy for Air Quality Management

Based on the study findings through analysis of long term ambient air quality data, ambient air quality data collected at several locations identified for the study, activity status of industries and subsequent stack emission characterization in representative industries, prevailing meteorological conditions in the region, contribution of major industrial sectors and identification of several other sources of air pollution in the region, air quality management strategy focusing mainly on major industrial sources is suggested. The strategy for air pollution control involves the following two types of emission sources in the industries:

- Control of process emissions through stacks
- Control of fugitive emissions in the industries

6.1 Control of Process Emissions in the Industries

In order to improve the air quality of the region, sound control/mitigation/management strategy is required for each source of air pollution. In industries, the major sources of air pollution include emissions through stacks and fugitive emissions from various activities carried out in the industries.

Emissions from the industries vary from one another greatly with respect to characteristics and quantity depending on the production capacity of the plant, type of fuel used, type and complexity of the processes employed, air pollution control measures in use and degree of maintenance in force and therefore, each industry needs particular/specific attention towards air pollution control/management. Technological means for control of air pollution from point sources are numerous, varied and can be fine tuned as per the requirements of the industrial unit. The air environment management plan recommended for control/minimization of process emissions through stack involves use of:

- Cleaner technology options
- Cleaner fuel options
- End-of-pipe/flue gas treatment
- Dispersion through tall stacks
- Changes in operational schedule to utilize air assimilative capacity.

These are discussed briefly in Table 6.1.1

Table 6.1.1: Emission Control Option for Industries with their Description

Emission Control Option	Description
Cleaner technology options	The industries should explore the possibility of manufacturing processes that lead to better process conversion efficiency, and result in lesser wastages (air, water, solid waste as well as heat loss). In fact, the industry should go for material balance and try to minimize generation of wastages per unit production of finished goods.
Cleaner fuel options	At present, F grade coal containing more than 40% ash content is used in most of the industries that results in generation of huge quantity of fly ash as well as bottom ash. The industries should explore the possibility using cleaner fuels such as natural gas, producer gas etc.
End-of-pipe/ flue gas treatment	The industries should aim to control the air emissions to the prescribed stack emission norms by installing adequate pollution control system like electrostatic precipitators, bag filters, cyclones, wet scrubbers, multi-cyclones etc. The industries already equipped with control system should regularly check its control efficiency and take appropriate measure to maintain the emission norms.
Dispersion through tall stacks	Increasing the height of stack is one of the options resulting in better dispersion of emissions released from industries. However, in an industrial complex, it is to be looked into in conjunction with all the industries existing in the region.
Changes in operational schedule to utilize air assimilative capacity	Atmospheric dilution and dispersion of pollutants released from the tall stacks take place through natural process of atmosphere. Towards evening, approaching sun set, dispersion of pollutants is often restricted, and in general, it becomes more severe in winter months. Therefore, the industries involving batch operation for a shift or so can reschedule their working hours to avoid trapping of pollutants under inversion conditions.

Major air polluting industries in the region are Sponge iron, Power plants, Ferro alloys, Rolling mills and Induction furnaces. Besides, there are many other small and medium scale industries involving combustion processes and handling & storage of various raw materials and finished products, which significantly influence the air quality in the study region. Some specific management plans that may be adopted by the industries are delineated below:

- Since most of the industries (Sponge iron, Power plants and Ferro alloy plants) are already equipped with adequate WHRB/ ESPs/ bag filters, efforts should be made to ensure proper functioning of these control systems. Further, efficiency of these control systems need to be evaluated on regular basis.

- Few rolling mills have installed dust control systems like settling chamber, cyclone, wet scrubber etc. However, the control efficiency of such systems needs to be evaluated on regular basis. It has been observed that significant amount of emissions were escaping from ingot heating/melting furnaces rather than being completely channelized through the air pollution control system and/or stacks, in several rolling mills. Proper care is needed to curb such process emission leakages.

- Like rolling mills, the same type of process fugitive emissions was observed in ferro alloy plants, where leakages occur through gaps in the hoods installed over each furnace.

- All the rolling mills should install proper pollution control systems, based on the specific process conditions of each mill. Suitable pollution control system package needs to be identified after in-depth study of these mills.

- Significant reduction in specific fuel consumption with better combustion and use of cleaner fuels to reduce emissions should be practiced. The quality of coal (F & E grade) used in the region contains high ash content (up to 45%), and use of better coal with less ash content needs to be explored.

- All the large and medium scale industries in the region should follow the CPCB guideline of providing a minimum of 30 m stack height and complying with emission standards for PM/SO_2/NOx etc. Any industry, which is unable to meet the emission standards, should go for the recommended options to keep the emissions under permissible levels.

6.2 Control of Fugitive Emissions in the Industries

Fugitive emissions are found to be one of the major sources of air pollution in industrial premises in Raipur region and efforts should be made to minimize the same within the industry itself. For control of fugitive emissions, each industry needs to make efforts to minimize generation of the same and in case it is inevitable, the industry should develop adequate green belt to confine fugitive emissions/leakages within the industry premises. Some specific control/management strategies for the industries are as follows:

- The industries should make efforts to reduce fugitive particulate matter emissions by providing proper storage and loading & unloading facilities, providing proper covers over conveyor belts & bucket elevators, and carrying out batch operations in enclosed sheds.

- During the study, it was found that movements of vehicles inside the industrial premises resulted in fugitive emissions from at least 14 out of 26 industries. Covering the raw materials by tarpaulin, limiting the speed of the vehicles and restricting the vehicle movement on unpaved roads could help in cutting down the fugitive emissions to a great extent.

- Unloading of the raw materials within the industrial premises is a major contributor to the fugitive emissions. Avoiding dropping of the raw materials from height could be a temporary approach, but the best practice is to unload and store the raw materials within an enclosure, which acts as a barrier and arrests the transport of the same by wind.

- Collection of ash from the control equipments should be done in closed collection chambers to entirely eliminate or minimize the drift of fly ash at the collection point; during the visit of the NEERI team it was observed that the drift and re-suspension from the collection points was a major source of fugitive emissions.

- Storage of the ash within the industrial premises should be done entirely in an enclosed area, and if the permanent structure is not available, a temporary provision to cover them with tarpaulin should be made.

- Loading of ash from the industrial area for final disposal should be done with utmost care. The ash must be entirely covered with tarpaulin while transporting to outside the industrial premises.

- Barren or uncovered soil blown by wind has also contributed to the fugitive emissions of the region, and all efforts to avoid/minimize the same are undertaken by many industries and some have succeeded in doing so by developing/covering the barren land area by vegetation/plantation. Green belt development within the industrial areas needs to be undertaken to the maximum extent possible in all the industries of Raipur region.

- In general, vegetative cover of the whole region, and in particular, that of industrial areas and individual industries needs to be increased. Green belts (GB) helps in capturing/ attenuating transport of pollutants mainly released at ground level, for example, re-suspension of road dust. Thus, location specific GB development plans and plantation schemes in the region are to be evolved to encircle the sensitive receptors and on both the sides along the heavy traffic avenues as well as major industry/industrial estates.

  In order to select the plant species suitable for pollution abatement through GB development, the appropriate selection is guided by their performance/response to pollution and also upon their economic/aesthetic value. Furthermore, the selected plant species should preferably be indigenous, fast growing, requiring minimal maintenance and self-rejuvenating. The afforestation should also be based on mixed type of plantation to support bio-diversity perpetuating local ecosystem.

  Plantation along the roads shall further help in attenuating vehicular emissions, as well as road dust generated due to movement of vehicles.

  Fugitive emissions from various industrial sources in the region, during various unit operations include SPM, SO_2, NOx, HC etc. The mitigation efficacy of green belt depends mainly on the width of green belt, distance from the source and tree height. Thus the green belt around industrial sources lowers the impact levels of fugitive emissions on the surroundings. The plantation pattern in a pollution hot spot may be undertaken in tune with site-specific attributes.

Summary of study findings and recommendations thereon including proposed action plans are presented in the next, and the last Chapter.

Chapter 7

Summary of Findings and Recommendations

Chapter 7

Summary of Findings and Recommendations

7.1 Summary of Findings

The study has been conducted keeping in view of the project objectives encompassing the scope of work envisaged. The findings of the study are summarized here followed by the recommendations and action plans.

7.1.1 Air Quality Status of Raipur Region

Analysis of Long term Secondary data

- Ambient air quality data generated under National Ambient Air Quality Monitoring Programme by CECB at three locations in Raipur city has been analyzed for RSPM, SPM, SO_2 and NO_2 for the period 2001 to 2008. Annual average values of air quality data indicated increasing trend in RSPM and SPM levels at residential and industrial areas during 2001 to 2004 and then a decreasing trend up to 2007. Further, increase in levels was observed in 2008.

- Similar trend was observed at commercial area/traffic activity zone. Overall, RSPM and SPM levels were found to be considerably high at all the three monitoring sites.

- Ambient air quality in terms of SO_2 levels showed gradual increase during 2002 to 2007, and then significant increase in 2008, as compared to previous year's concentration levels at all the three locations. Almost similar trend was observed for NO_2 concentration levels. Though the concentration levels of SO_2 (18-20 $\mu g/m^3$ in 2008) were within the permissible limit of 50 $\mu g/m^3$, however, over the years, increasing trends were observed at all the three monitoring locations. The concentration levels of NO_2 were marginally within the permissible limit of 40 $\mu g/m^3$ during 2001-2007, but these levels had exceeded (42-45 $\mu g/m^3$) at all the three monitoring locations in 2008. Thus, there is a need for immediate action for controlling these air pollutants, namely RSPM and NO_2. Air quality status in terms of annual average concentration levels of RSPM, SPM, SO_2 and NO_2 for the year 2008 is presented along with the prescribed CPCB standards in **Table 7.1.1**.

Table 7.1.1: Air Quality Status of Raipur City in 2008

Area Classification	Annual Average Concentration of Pollutants ($\mu g/m^3$)			
	RSPM	SPM	SO_2	NO_2
Residential Area	186	380	20	45
Commercial Area	174	320	20	44
Industrial Area	218	393	18	42
CPCB Standard (Annual mean)	60	--	50	40

Analysis of Primary Data

- Keeping in view the study objectives, for major criteria pollutants, viz. SPM, RSPM (PM_{10}), SO_2 and NO_2 were monitored at 8 locations continuously for 8 days in the Raipur region during critical winter season (January 2009). Sampling was carried out on 8 hourly basis, representing 3 shifts as 06-14 hrs, 14-22 hrs and 22-06 hrs so that the variations in activities of different sources within a day are represented in the monitoring results.

- All the monitoring sites were divided under two broad categories as Urban sites and Rural sites. The monitoring sites at Jai Stambh Chowk, Khamtarai, Kabir Nagar and Telecom Nagar were designated as Urban sites, whereas monitoring sites at Dhaneli, Sondra, Kumhari and Dharsiwa were designated as Rural sites. Range of measured 24 hourly average concentrations of RSPM, SPM, SO_2 and NO_2 at 4 Urban and 4 Rural sites is summarized along with applicable CPCB standards in **Table 7.1.2**.

Table 7.1.2: Range of 24 Hourly Average Concentrations of Ambient Air Quality Parameters in Raipur Region: January 2009

Area Classification	Range of Average Concentration of Pollutants ($\mu g/m^3$)			
	RSPM	SPM	SO_2	NO_2
Urban Sites	184-435	211-658	19-51	37-49
Rural Sites	135-312	188-618	13-38	19-47
CPCB Standard (24 hourly average)	**100**	--	**80**	**80**

- Analysis of air quality data (in terms of SPM & RSPM) indicated Kabir Nagar as the most polluted site, followed by Telecom Nagar and Jai Stambh Chowk, whereas among the Rural sites, Sondra was found to be the most polluted site. Measured RSPM levels exceeded considerably the CPCB Standards all the sites. High levels of SPM and RSPM could be attributed to many sources like industrial emissions, traffic movement, road dust re-suspension, construction activities, agricultural activities, etc. prevailing in the region.

- 24 hourly average concentration levels of SO_2 and NO_2 were observed to be within the permissible levels of 80 $\mu g/m^3$. Highest average concentration of SO_2 (51 $\mu g/m^3$) and NO_2 (49 $\mu g/m^3$) was observed at Jai Stambh Chowk, which may be attributed to traffic and commercial activities, particularly hotel & restaurants existing in that area.

- Diurnal variation in air quality data indicated maximum pollution during 14-22 hrs at most of the monitoring sites.

- Other gaseous pollutants like CO and HC were also monitored for a limited period to get the preliminary idea about their existing concentrations in the Raipur region. One hour average concentration levels of specific gaseous pollutants. CO and total hydrocarbon (THC including methane & non-methane). indicated highest concentration of CO (2.194 ppm) and total HC (8.91 ppm) at the Jai Stambh Chowk

- RSPM samples collected at all the monitoring sites were characterized for their chemical constituents, cations (Na^+, K^+, Ca^{2+}, Mg^{2+} and NH_4^+), anions (SO_4^{2-}, NO_3^-, Cl^- and F^-) and heavy metals (Fe, Cu, Cd, Cr, Zn, Pb, Co, Ni & Mn). Sodium, Calcium, Potassium, Sulfate, Nitrate, Chloride and Iron were found to be the main chemical constituents of the RSPM samples, indicating the impact of industrial emissions along with other sources of air pollution like traffic, road dust re-suspension, construction activities, agricultural activities and combustion of fuels in different activities.

- In the measured RSPM concentrations at all the monitoring sites, the chemical constituents identified were 48.2% at Urban sites, and 43.7% at Rural sites, with an overall identified mass of 45.9%. The remaining mass could be in the form of elemental carbon, organic carbon, silica and many other ions and metals.

- Based on the monitored levels of ambient air quality parameters in Raipur region, the three most affected sites are identified, as presented in **Table 7.1.3**, which indicates that among the monitored sites, Kabir Nagar, Telecom Colony, Sondra and Dhaneli are the most pollution affected sites/areas in the Raipur region.

Table 7.1.3: Ranking of Monitoring Sites in terms of Air Quality Parameters and Chemical Speciation of Particulate Matter

Parameters	Ranking as Highest Level of Pollution		
	First	Second	Third
Air Quality			
RSPM/PM_{10}	Kabir Nagar	Sondra	Telecom Colony
SPM	Kabir Nagar	Sondra	Telecom Colony
Sulfur dioxide (SO_2)	Jai Stambh Chowk	Dhaneli	Khamtarai
Nitrogen dioxide (NO_2)	Jai Stambh Chowk	Dhaneli	Sondra
Cations			
Sodium (Na^+)	Sondra	Telecom Colony	Jai Stambh Chowk
Potassium (K^+)	Sondra	Telecom Colony	Kabir Nagar
Calcium (Ca^{2+})	Kabir Nagar	Telecom Colony	Sondra
Magnesium (Mg^{2+})	Kabir Nagar	Dhaneli	Sondra
Ammonium (NH_4^+)	Kumhari	Jai Stambh Chowk	Kabir Nagar
Anions			
Sulfate (SO_4^{2-})	Kabir Nagar	Telecom Colony	Sondra
Nitrate (NO_3^-)	Kabir Nagar	Telecom Colony	Sondra
Chloride (Cl^-)	Kabir Nagar	Sondra	Dhaneli
Fluoride (F^-)	Kabir Nagar	Telecom Colony	Dhaneli
Metals			
Iron (Fe)	Kabir Nagar	Sondra	Dhaneli
Copper (Cu)	Kabir Nagar	Sondra	Kumhari
Lead (Pb)	Khamtarai	Dhaneli	Sondra
Manganese (Mn)	--	--	--
Zinc (Zn)	Kabir Nagar	Sondra	Telecom Colony

7.1.2 Stack Emissions Characterization

- Stack emissions monitoring with special emphasis on particulate matter concentrations in representative industries of Sponge Iron, Power Plant, Ferro Alloy Plant and Rolling Mills was carried out. Stack monitoring results along with stack details are summarized in **Table 7.1.4**.

Table 7.1.4: Summary of Stack Details with Measured Particulate Matter Concentrations in Representative Industries

Industry	No. of Stacks Moni-tored	Stack Height (m)	Dia-meter (m)	Control System	Flue Gas Temp. (K)	Flue gas Velocity (m/s)	Volumetric Flow rate (Nm^3/hr)	PM Conc. (mg/Nm^3)	PM Load (Kg/hr)
Sponge Iron Plants	6	44-70	2.4-3.92	ESP, Eff. 98.5-99.7%	383-441	4.7 - 6.9	65,000-5,26,000	10 -146	0.7-20.7
Captive Power Plants	5	42-90	1.0 - 3.9	ESP, Eff. 98.5-99.7%	378-417	2.7 - 9.8	58,000-2,26,000	31 - 196	6.0-11.6
Ferro Alloy Plants	4	30-40	0.8 - 1.8	Bag filter	326-361	4.2 - 12.4	17,700-30,900	3 - 115	0.1-1.8
Rolling Mills	4	40-75	0.5 - 0.6	Cyclone scrubber	318-520	2.5 - 16.5	1,700 - 4,000	28 - 201	0.06 - 0.34

- Further, chemical characterization of particulate matter in terms of cations (Na^+, K^+, Ca^{2+}, Mg^{2+} & NH_4^+, anions (SO_4^{2-}, NO_3^-, Cl^- & F^-), and heavy metals (Fe, Cu, Cr, Cd, Zn, Co, Ni, Pb & Mn) was carried out. Average concentrations of different cations, anions and heavy metals are summarized in **Table 7.1.5.**

Table 7.1.5: Average Concentrations of Cations, Anions and Heavy Metals in Stack Particulate Matter Samples

Parameter	Average Concentration, (mg/Nm^3)			
	Sponge Iron Plants	Captive Power Plants	Ferro Alloy Plants	Rolling Mills
Particulate Matter	63	99	70	117
Cations				
Sodium (Na^+)	7.27	10.10	5.30	9.99
Potassium (K^+)	0.45	0.62	1.37	0.57
Calcium (Ca^{2+})	2.34	6.75	3.07	3.24
Magnesium (Mg^{2+})	0.98	0.34	BDL	0.43
Ammonium (NH_4^+)	1.45	0.40	0.32	0.89
Anions				
Sulfate (SO_4^{2-})	8.04	15.85	11.91	19.25
Nitrate (NO_3^-)	1.52	6.30	0.02	10.13
Chloride (Cl^-)	7.25	4.01	6.50	1.31
Fluoride (F^-)	5.20	6.29	0.69	1.02
Heavy Metals				
Iron (Fe)	1.52	1.39	0.50	1.14
Copper (Cu)	0.02	0.02	0.01	0.07
Lead (Pb)	BDL	BDL	0.06	0.05
Manganese (Mn)	0.02	0.02	5.28	0.03

- It was found that particulate matter concentration was highest in Rolling mills, followed by Power Plant, Sponge Iron and Ferro Alloy Plants. Na^+ was contributed by Power Plants and Rolling Mills, whereas K^+ was contributed by Ferro Alloy Plants. Highest Ca^{2+} was emitted from Power Plants. Sponge Iron Plants contributed Mg^{2+} and NH_4^+.

- SO_4^{2-} were contributed by all types of industries, highest being from Rolling mills. Similarly, NO_3^- was contributed by all types of industries (except Ferro Alloy), highest being from Rolling mills. Sponge Iron Plants topped in Cl^-, whereas Power Plants topped in F^- contribution. Sponge Iron, Power Plants and Rolling Mills contributed Fe, whereas Ferro Alloy Plants emitted Mn.

- Analysis of chemical constituents of particulate matter samples in the stack gas in different industries indicated that out of the total measured PM concentration, the chemical constituents had a share of 57.1% in Sponge iron plants, 52.4% in Power plants, 50.2% in Ferro alloy plants and 41.2% in Rolling mills. The remaining unidentified mass could be in the form of elemental carbon, organic carbon, silica and other ions and metals.

- Finally, based on the average concentration levels of particulate matter and their chemical characteristics, different industrial sectors have been ranked, as presented in Table 7.1.6.

Table 7.1.6: Ranking of Industrial Sectors in terms of Particulate Matter in Stack and its Chemical Constituents

Parameter	Ranking of Industry Sector			
	First	Second	Third	Fourth
PM Conc.	Rolling Mills	Power Plant	Ferro Alloy	Sponge Iron
Cations				
Sodium (Na^+)	Power Plant	Rolling Mills	Sponge Iron	Ferro Alloy
Potassium (K^+)	Ferro Alloy	Power Plant	Rolling Mills	Sponge Iron
Calcium (Ca^{2+})	Power Plant	Rolling Mills	Ferro Alloy	Sponge Iron
Magnesium (Mg^{2+})	Sponge Iron	Power Plant	Rolling Mills	Ferro Alloy
Ammonium (NH_4^+)	Sponge Iron	Rolling Mills	Power Plant	Ferro Alloy
Anions				
Sulfate (SO_4^{2-})	Rolling Mills	Power Plant	Ferro Alloy	Sponge Iron
Nitrate (NO_3^-)	Rolling Mills	Power Plant	Sponge Iron	--
Chloride (Cl^-)	Sponge Iron	Ferro Alloy	Power Plant	Rolling Mills
Fluoride (F^-)	Power Plant	Sponge Iron	Rolling Mills	Ferro Alloy
Metals				
Iron (Fe)	Sponge Iron	Power Plant	Rolling Mills	Ferro Alloy
Manganese (Mn)	Ferro Alloy	--	--	--

- It is pertinent to mention that the average concentration (in mg/Nm^3) of particulate matter, SO_4^{2-} and NO_3^- are highest in Rolling Mills, whereas concentration of Na^+, Ca^{2+} & NH_4^+ are second highest in Rolling mills. Considering the volumetric flow rate of flue gases in Rolling Mills, total amount/emission load (in kg/hr or kg/day) from Rolling Mills could be much less as compared to Sponge Iron or Power Plants.

7.1.3 Contribution of Industrial Sources to Ambient Air Quality

Estimation of PM Emission Load

- Particulate matter emission load was estimated for major air polluting industries. Highest PM emissions were estimated to be contributed by sponge iron plants (5,547 kg/d), followed by power plants (5,095 kg/d) and rolling mills (4,293 kg/d), whereas ferro alloy plants contributed only 1,364 kg/d of PM emissions. Similarly, total emission loads for iron and manganese were also estimated. Among the four industrial sectors, sponge iron industries contributed highest particulate matter (34%) and iron (52.1%), followed by power plants and rolling mills. Ferro alloy plants contributed as much as 96.4% of manganese, and the balance 3.6% was contributed by the sponge iron, power plants and rolling mills

- Total emission load of cations, anions and metals contributed by these industry sectors have been estimated considering the average concentration of these parameters in the stack gas particulate matter samples. The total emission load of Na^+, K^+, Ca^{2+}, Mg^{2+} and NH_4^+ ions from all the major air polluting industries is estimated to be 1629.7 kg/d, 119.1 kg/d, 732.1 kg/d, 119.6 kg/d and 187.2 kg/d, respectively. The total emission load of SO_4^{2-}, NO_3^-, Cl^- and F^- is estimated to be 2462 kg/d, 830.2 kg/d, 1019.4 kg/d and 832.4 kg/d, respectively.

- Sponge iron industries contributed highest percentage of Mg^{2+}, NH_4^+, Na^+ and K^+ ions, whereas highest Ca^{2+} ion was contributed by power plants. In general, sponge iron and power plants accounted for 70-87% of different cations in particulate matter. Similarly, Sponge iron industries also contributed chloride, fluoride and sulfate significantly. Power plants contributed mainly nitrate, sulfate and fluoride, whereas rolling mills contributed nitrate. Emissions of ions from Ferro alloy stacks were found to be the least.

- Considering the total emission load of particulate matter (16.3 tons/day) from all the major air polluting industries, 51% chemical constituents in terms of cations, anions and heavy metals had been identified.

- Based on emission inventory, the total particulate matter emitted by all the industries is estimated to contain 30% Sulfates, 20% Sodium, 12% Chlorides, 10% Fluorides, 10% Nitrates and 9% Calcium, whereas Iron is about 3% and other constituents contribute about 6%.

7.1.4 Industrial Source Contribution to Ambient Air Quality

- Impact of industrial emissions with respect to particulate matter and its iron content was predicted using ISCST3 air quality model. Particulate matter emission rate was measured through actual monitoring in stacks of selected representative industries. In order to cover the wider range of possible emissions, three scenarios were considered.

  Scenario 1: All the industries are emitting upper range of PM concentrations (based on measured concentration in respective representative industries)

  Scenario 2: All the industries are emitting average PM concentrations (based on measured concentration in respective representative industries)

  Scenario 3: All the industries are emitting PM concentration within the permissible levels (Sponge iron, Power plant and Ferro alloy - 50 mg/Nm^3; Rolling mills - 150 mg/Nm^3)

- The contribution of four major air polluting sectors, viz. sponge iron, power, ferro alloy and rolling mills, existing mainly in Siltarta & Urla industrial areas and their adjoining areas has been estimated on ambient air of the Raipur region through dispersion modeling using ISCST3 air quality model. The meteorological data required for the modeling study was collected by setting up a meteorological station at M/s Shri Bajrang Power and Ispat Ltd., which was considered as the centre of study region during the month of February and March 2009. All the meteorological parameters were monitored on hourly basis of the day. It was observed that during February, calm conditions prevailed (wind speed less than 0.5 m/s) for 28.7% of the time, whereas in March calm conditions prevailed for lesser duration (17.1%), indicating that better dispersion conditions prevail during March as compared to the February.

- The model predicted results were compared with the actual measured concentration values of particulate matter and its iron content at 8 monitoring locations under two emission scenarios (discussed in Chapter 5). Ratio of predicted concentration, (representing contribution of industrial emissions) to the measured concentration of PM at different monitoring locations were estimated.

- Percent ratios of predicted concentration to the measured concentrations are found to be in the range of 3.9% to 13.3% at Urban sites and 6.0-12.5% at Rural sites. Overall average percent ratio is found to be 8.0% under Scenario 1, 4.1% under Scenario 2 and 3.7% under Scenario 3. Based on model results for Fe content in particulate matter, the overall average contribution of industrial emissions is found to be only 6.6% under Scenario1 and 2.7% under Scenario 2.

- In summary, predicted concentrations at all the sites are found to be much less as compared to the measured concentration levels of particulate matter under the given conditions and assumptions considered in the study. This may be due to several factors as discussed in the next section.

7.1.5 Identified other Sources of Air Pollution in Raipur Region

From the analysis of predicted and measured concentration levels of particulate matter and its chemical characterization in the present study, it has been estimated that the contribution of particulate matter from the stacks of major air polluting industries to the ambient air quality (in terms of particulate matter) is of the order of 13% (varies at different locations). It is pertinent to mention that the estimated contribution of industrial emissions to the ambient air quality of Raipur region needs to be looked at with due consideration to the numerous variations/ uncertainties associated with various factors and conditions of various sources of air pollution present in the study region, and assumptions and limitations of estimation and monitoring techniques and air quality modeling. Other sources of air pollution identified in the Raipur region as are follows:

- Contribution of large number of small and medium scale industries existing in the region, besides major air polluting industries (sponge iron, power, ferro alloy and rolling mills)
- Fugitive emissions arising due to transport & handling of various input materials and finished products, solid waste (bottom ash, fly ash etc.), re-suspension of settled dust due to movement of trucks in and around the industries
- Actual emissions released from different industries may vary considerably depending upon the process and operating conditions in each of the industries, thereby affecting the predicted GLCs
- Movement of large number of heavy duty vehicles (loaded & unloaded trucks) in the region, resulting in exhaust emissions
- Re-suspension of road dust due to movement of vehicles/wind. Poor conditions of roads/vehicles further enhance its magnitude
- Movement of vehicles on unpaved roads
- Spillage of materials from loaded transport vehicles
- Improper dumping/disposal of industrial solid wastes, mainly bottom ash, fly ash etc. in low lying areas
- Agricultural activities in the region and use of different types of fuels like wood/dung cake, coal etc in villages
- Barren and loose topsoil of the region gets easily thrown away in the atmosphere by wind and movement of vehicles
- Other sources of air pollution include vehicular emissions, combustion of fuels in rural and urban households and also for various other commercial activities, refuse/

garbage/ agricultural waste burning, re-suspension of road dust due to unpaved/ poor conditions of roads/vehicles etc.

- Large number of infrastructure activities like construction of buildings, roads, bridges etc., being undertaken in the region also contribute to fugitive dust emissions.

Air quality monitoring site-wise predicted contribution of industrial sectors and other possible other sources influencing air quality in terms of particulate matter are summarized in **Table 7.1.7**.

Table 7.1.7: Site-wise Predicted % Contribution of Industrial Sectors (in terms of Particulate Matter under Scenario 1) and Identified Other Sources of Air Pollution

Monitoring Site	Measured PM Conc., (μg/m^3)	Predicted Maximum Contribution of Industrial Sectors, (%)	Other Sources of Air Pollution
Urban Sites			
Jai Stambh Chowk	184	9.0	Commercial activities, fuel combustion in hotels & restaurants, residential areas, high intensity traffic (mainly 2, 3 & 4 wheelers)
Khamtarai	187	13.3	Residential colonies including slum areas, proximity to saw mills, railway line, use of low quality fuels like coal balls
Kabirnagar	435	3.9	Recently developed residential area, construction activities, loose soil/road dust, proximity to NH6, high intensity heavy duty traffic
Telecom Colony	274	6.8	Mainly residential area with congested colonies, limited commercial and traffic activities
Rural Sites			
Dhaneli (near Siltara Industrial area – Phase I)	234	12.5	Rural area setting, proximity to agricultural fields/activities and national highway with high intensity heavy duty traffic, poor condition of roads, lifting of road dust
Sondra (near Siltara Industrial area – Phase II)	312	8.1	Rural area setting, proximity to agricultural fields/activities and large industries with low intensity traffic, poor condition of roads, lifting of road dust
Kumhari	135	9.4	Rural area setting, proximity to agricultural fields/activities, earthen pots making and baking with locally available fuels, brick kiln, poor condition of roads, lifting of road dust
Dharsiwa	136	6.0	Rural area setting, proximity to agricultural fields/activities and national highway with high intensity heavy duty traffic, poor condition of roads, lifting of road dust

7.1.6 Strategy for Air Quality Management

In order to minimize the problem of air pollution caused by various sources of air pollution, a multi-sectoral approach involving different stakeholders needs to be adopted in the Raipur region. The air pollution control/mitigation strategies and management plans which will lead to improvement in air quality of Raipur region are delineated, mainly for the control of emissions from stacks and fugitive emissions occurring in the industries.

In order to improve the overall ambient air quality of the whole Raipur region, efforts are required to control/mitigate/manage other sources of air pollution also, as identified in the study.

Based on the study findings, the recommendations made are presented along with proposed action plans in the next section.

7.2 Recommendations

In order to achieve compliance to stack emission guidelines and standards and also to reduce air pollution within industry premises for the selected industrial units in Raipur, based on the study findings, the following measures are recommended:

- Control of fugitive emissions in all the industries
- Adherence to strict stack emission norms by all the industries
- Use of low 'S' fuels / install 'S' control systems in the industries
- Construction of Pucca motorable roads within the industries including approach roads
- The roads in industrial areas should be of adequate width to avoid movement of vehicles on unpaved roads while crossing and the roads should be properly maintained
- Green belt development all along the roads within industries/ industrial areas
- Periodic performance evaluation of control systems should be done by the industries and the efficacy of efforts made by the industries towards pollution control should be evaluated through independent agency on regular basis.
- All the industries should have adequate provision (wide platform, caged staircase/ ladder, wide port hole of at least 6" diameter, 15 amp power connection) for monitoring of stack emissions at the inlet and outlet of control systems to evaluate their efficacy
- Adequate roads for dust free movement of heavy duty vehicles in the region

- Strict I&M practice for heavy duty and commercial vehicles

- Sufficient roads (dust free) for movement of other vehicles with synchronized signals and proper parking places to avoid congestion

- Restrict/ban use of low quality coal/fine powder coal balls as domestic fuel (industries should initiate for better use with control system)

- Latest automatic ash handling systems with silos should be attached to all ESPs to check wanton dumping of the collected dust in the open which would aid in minimizing their fugitive emissions

- To utilize the dolochar generated in the sponge iron plants, setting up of dolochar based captive power plants in the region may be explored, through consortia of interested group of industries. However, any such proposal needs to be critically scrutinized in view of the existing high levels of particulate matter in the region

- Proper and controlled disposal of industrial solid wastes (bottom ash, slag, fly ash etc.) in identified low lying areas only, should be practiced. However, efforts should be made to utilize these wastes to the extent possible for various applications, like road construction, cement manufacture, brick manufacturing, park development in low lying areas, and in agriculture. A detailed study on 'Sustainable Utilization of Industrial Solid Wastes in Raipur region' is warranted on priority.

- A comprehensive computerized data base on different industry sectors should be prepared, which can be utilized for preparation of emission inventory and developing strategies for air pollution mitigation. Such data base/emission inventory should be updated on yearly basis.

- Periodic monitoring of air quality of Raipur region to evaluate effectiveness of pollution control measures adopted by the industries is required. Such study should be carried out through an independent agency.

- There is also a need to create awareness among the various industries towards environmental management. The industries should organize conferences/ seminars on environmental aspects on regular basis to discuss/share environmental management practices adopted by them and how they can further improve their own environmental management system.

- There is a need for periodic training to the staff engaged in environmental management of the industries, who later on can review the environmental management practices of their own company and may also provide support to other industries

- An action plan towards environmental management needs to be prepared by each industry and its effectiveness should be evaluated by an independent agency. Further, the industry having the best environmental practices may be awarded and given incentive by the regulatory agency

7.3 Proposed Action Plans

In order to control/mitigate air emissions from industries, and to improve air quality of the Raipur region, the measures suggested based on the study carried out in the region, needs to be implemented as per the proposed action plan given below in **Table 7.3.1**.

Table 7.3.1: Proposed Action Plan for Air Quality Management in Raipur Region

Sr. No.	Activity/Task	Accountability	Reporting Agency	Time Target
	Initiatives to be taken by Industries			
1.	Training to the environmental managers of respective industries (sector-wise)	Agency as identified by CECB	CECB	
2.	Preparation of industry specific environment management plan (including process & fugitive emissions, paving of roads and green belt development)	Environmental Managers of respective industries	CECB	
3.	Implementation of environment management plan by respective industries	Industry Management		
4.	Evaluation of effectiveness of EMP adopted by industries (representative industries)	Agency as identified by CECB	CECB	
5.	Sharing of environmental management practices adopted by industries through periodic Conferences/ Workshops	Industry associations	CECB	
6.	Ensure adherence to emission norms in industries	CECB		
7.	Periodic performance evaluation of control systems installed in the industries	Third party as identified by CECB	CECB	
8.	Adequacy of roads with proper maintenance in industrial areas	CSIDC		
	Initiative to be Taken by the Government			
9.	Adequacy of roads with proper maintenance in Raipur city and adjoining areas	PWD/NHA		
10.	Green belt development in Raipur city	Raipur Municipal Corporation	CECB	
11.	Strict I& M practice for heavy duty and commercial vehicles	Transport department	CECB	
12.	Ban on refuse burning in urban areas	RMC	CECB	
13.	Ban on use of low quality coal/coal powder balls as domestic fuel	RMC	CECB	
14.	Periodic monitoring of air quality of Raipur region to evaluate effectiveness of various pollution control measures	Third party as identified by CECB	CECB	
15.	Incentives/awards to eco-friendly industries	Third party evaluation	CECB	
16.	Preparation of comprehensive data base of all industrial sectors	Industries associations/ CECB	CECB	
17.	Conducting Future Studies	Research Institutes	CECB	

Strategy for implementation of the above action plans, and action specific time targets are to be decided by the regulatory agency and the respective implementing agency.

Annexure

Table A.1.1: Revised National Air Quality Standards (MoEF Notification, Nov 18, 2009)

Sr. No.	Pollutants	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (Notified by Central Government)	
1.	Sulfur Dioxide (SO_2), µg/m^3	Annual	50	20	- Improved West & Gaeke - Ultraviolet fluorescence
		24 hours	80	80	
2.	Nitrogen Dioxide (NO_2), µg/m^3	Annual	40	30	- Modified Jacob and Hochheiser (Na-Arsenite) method - Chemiluminescence
		24 hours	80	80	
3.	Particulate matter (size less than 10 µm), µg/m^3	Annual	60	60	- Gravimetric - TEOM - Beta attenuation
		24 hours	100	100	
4.	Particulate matter (size less than 2.5 µm), µg/m^3	Annual	40	40	- Gravimetric - TEOM - Beta attenuation
		24 hours	60	60	
5.	Ozone (O_3), µg/m^3	8 hours	100	100	- UV Photometric - Chemiluminescence - Chemical Method
		1 hour	180	180	
6.	Lead (Pb), µg/m^3	Annual	0.5	0.50	- AAS/ICP method after sampling on EPM 2000 or equivalent filter paper - ED-XRF using Teflon filter
		24 hours	1.00	1.00	
7.	Carbon monoxide (CO), mg/m^3	8 hours	2.0	1.0	- Non – Disperse Infrared (NDIR) Spectroscopy
		1 hour	4.0	2.0	
8.	Ammonia (NH_3), µg/m^3	Annual	100	100	- Chemiluminescence - Iodophenol blue method
		24 hours	400	400	
9.	Benzene (C_6H_6), µg /m^3	Annual	05	05	- Gas chromatography based continuous analyzer - Adsoprtion and desorption followed by GC analysis
10.	Benzo (a) Pyrene (BaP), particulate phase only, ng/m^3	Annual	01	01	- Solvent extraction followed by HPLC/GC analysis

Table A.1.1 Contd...

Sr. No.	Pollutants	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (Notified by Central Government)	
11.	Arsenic (As), ng/m^3	Annual	06	06	- AAS/ICP method after sampling on EPM 2000 or equivalent filter paper
12.	Nickel (Ni), ng/m^3	Annual	20	20	- AAS/ICP method after sampling on EPM 2000 or equivalent filter paper

- Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.
- 24 hourly or 8 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limit but not on two consecutive days of monitoring

Note: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation

Table B.2.1: List of Sponge Iron and Power Plants in Raipur Region

Sr. No.	Name of the Industry
	Siltara Industrial Area
1*.	M/s Sarada Energy and Minerals Ltd., Industrial Area Siltara, Phase-1, Raipur
2*.	M/s Godavari Power and Ispat Ltd., Industrial Area Siltara, Phase-1, Raipur
3*.	M/s Vandana Global Private Ltd., Industrial Area Siltara, Phase-2, Raipur
4*.	M/s S. K. S. Ispat Private Ltd., Industrial Area Siltara, Raipur
5.	M/s Droliya Electrosteels Private Ltd., Siltara, Raipur
6*.	M/s Mahendra Sponge and Power Private Ltd., Industrial Area Siltara, Phase-2, Raipur
7*.	M/s N. R. Sponge Private Ltd., Gram Bahesar, Siltara, Raipur
8*.	M/s Shree Nakoda Ispat Ltd., Industrial Area ,Siltara, Phase-2, Raipur
9*.	M/s Baldev Alloys Private Ltd., Siltara, Raipur
10.	M/s S.K. Saravagi and Company Private Ltd., Industrial Area Siltara, Phase-2, Raipur
11.	M/s Gagan Resources Private Ltd., Muraithi, Siltara, Raipur
12*.	M/s Rashmi Sponge Iron and Power Industries, Siltara, Raipur
13*.	M/s Indian Steel and Power Private Ltd., Gram Charoda, Siltara, Raipur
14.	M/s Arti Sponge and Power Ltd., Siltara, Raipur
15*.	M/s Gopal Sponge and Power Private Ltd., Siltara, Raipur
16.	M/s Mahamaya Sponge Iron Private Ltd., Industrial Area Siltara, Phase-1, Raipur
17.	M/s Shree P.D. Industries Private Ltd., Siltara, Raipur
18.	M/s Agarwal Sponge Private Ltd., Siltara Growth Centre, Phase-2, Raipur
19.	M/s Shree Harekrishna Sponge Iron Private Ltd., Siltara, Phase-2, Raipur
20*.	M/s G. R. Sponge and Power Ltd., Siltara, Phase-2, Raipur
21.	M/s Sunil Sponge Private Ltd., Siltara, Phase-2, Raipur
22.	M/s Ghankun Steel Private Ltd., Gram Sondra, Siltara, Raipur
23*.	M/s Devi Iron and Power Private Ltd., Gram Tada, Siltara, Raipur
24.	M/s Abhijeet Infrastructure Private Ltd., Girod, Siltara, Raipur
25.	M/s Vaswani Industries Ltd., Sondra, Siltara, Raipur
26.	M/s Euro Pratik Ispat Private Ltd., Gram Tada, Siltara, Raipur
27*.	M/s Bhagvati Power and Steel Private Ltd., Siltara, Raipur
28*.	M/s A. P. I. Ispat and Powertech, Siltara, Raipur
29.	M/s Trimula Sponge Iron Private Ltd., Siltara, Raipur
30.	M/s Raimata Ispat India Private Ltd., Gram Charoda, Siltara, Raipur
31.	M/s Corporate Ispat and Alloys Ltd., Siltara, Raipur
32.	M/s Ramnivas Ispat Private Ltd., Siltara, Raipur
	Borjhara-Urla Industrial Area
33*.	M/s Shee Bajrang Power and Ispat Ltd., Borjhara, Urla, Raipur
34*.	M/s Satayarth Steel and Power Pvt. Ltd., Borjhara, Raipur
35*.	M/s Shivalaya Ispat and Power Private Ltd., Gram Kara, Guma Urla, Raipur
36*.	M/s Shree Sita Ispat and Power Private Ltd., Gram Borjhara, Guma Urla Road, Raipur
37.	M/s Real Ispat Private Ltd., Borjhara, Urla, Raipur
38.	M/s Shilphi Steel Private Ltd., Sarora, Urla, Raipur
39.	M/s Gravity Trexim Private Ltd., Gram Achholi, Urla Raipur
	Exclusive Power Generation Plants
40.	M/s Jagdamba Power and Alloys Ltd., Muraithi, Siltara Phase - II, Raipur
41.	M/s Maa Usha Urja, Siltara Industrial Area, Raipur
42.	M/s Shree Bajrang Metalics and Power Ltd., Urla, Raipur

*with Power Generation Unit

Table B.2.2: List of Ferro Alloy and Power Industries in Raipur Region

Sr. No.	Name of Industry
	Urla Industrial Area
1.	M/s Raghuveer Ferro Alloys Pvt. Ltd., Industrial Area Urla, Raipur
2.	M/s Shri Niwas Ferro Alloys Pvt. Ltd., Industrial Area Urla, Raipur
3.	M/s Shri Girija Smelters Pvt. Ltd., Industrial Area Urla, Raipur
4.	M/s Hira Ferro Alloys (Unit-I), Industrial Area Urla, Raipur
5.*	M/s Hira Ferro Alloys (Unit-II), Industrial Area Urla, Raipur
6.*	M/s Indsil Energy & Electro-chemicals Ltd., Industrial Area Urla, Raipur
7.	M/s Deepak Ferro Alloys Ltd., Industrial Area Urla, Raipur
8.	M/s Heera Power and Steel Ltd. (Unit - I), Industrial Area Urla, Raipur
9.*	M/s Heera Power and Steel Ltd. (Unit - II), Industrial Area Urla, Raipur
10*.	M/s Alok Ferro Alloys, Urla, Raipur
11.	M/s Monnet Ispat & Energy Ltd., Industrial Area Urla, Raipur

*with Power Generation Unit

Table B.2.3: List of Rolling Mills in Raipur Region

Sr. No.	Name of Industry
1.	M/s Raipur Ispat Udyog, Industrial Area Sarora, Raipur
2.	M/s Hanukripa Ispat Pvt. Ltd., I/A Urla, Raipur
3.	M/s C.G. Ispat Pvt. Ltd., Bahesar, Dharsiwa, Raipur
4.	M/s Shiv Real Ispat Pvt. Ltd., Rawabhata, Raipur
5.	M/s Swastik Steels, near Rawabhata, Raipur
6.	M/s Radharani Steels Pvt. Ltd., Bendri, Borjhara, Raipur
7.	M/s Harsiddhi Rolling Mill Pvt. Ltd., Gogaon, Raipur
8.	M/s Varun Steel, Bhanpuri, Raipur
9.	M/s Ambey Ispat, Gogaon, Sondongari, Raipur
10.	M/s V.K. Steel, Sarora, Urla, Raipur
11.	M/s Ratu Saria Steel Pvt. Ltd., Urla, Raipur
12.	M/s Shri Mohan Products, Borjhara, Raipur
13.	M/s B.S. Petrochemical Pvt. Ltd. (Steel Division), Achholi, Urla Raipur
14.	M/s Shri Ram Steel Corporation, Sankra, Raipur
15.	M/s Rajesh Steel Industry, Tatibandh, Raipur
16.	M/s Birmiwal Steel Pvt. Ltd., Sarora, Urla Raipur
17.	M/s Sindh Ispat, Rawabhata, Raipur
18.	M/s Goyal Energy & Steel Pvt. Ltd., Tatibandh, Raipur
19.	M/s U.P. Structures Pvt. Ltd., Sondongari, Raipur
20.	M/s G.S. Iron Pvt. Ltd., Siltara, Raipur
21.	M/s New Tech Ispat Pvt. Ltd., Tatibandh, Raipur
22.	M/s Satya Shyam Steels Pvt. Ltd., Muraithi, Siltara Raipur
23.	M/s Shri Ram Rolling Mill, Rawabhata, Raipur
24.	M/s Shiv Shakti Ispat, Bhanpuri, Raipur
25.	M/s Vindhya Iron & Steel Pvt. Ltd., Village Tada, Raipur
26.	M/s Prem Polymers, Urla, Raipur
27.	M/s Chhattisgarh Steel Products, Urla, Raipur
28.	M/s Alankar Re-Rollers Pvt. Ltd., Urla, Raipur
29.	M/s Agrawal Structure Mills Pvt. Ltd., Beergaon, Urla, Raipur
30.	M/s A.C. Strips Pvt. Ltd., Urla, Raipur
31.	M/s R.K. Ispat Udyog, Sondongari, Raipur

32.	M/s Mahalaxmi Steel Industries, Gogaon, Raipur
33.	M/s Aditya Steels, Urla, Raipur
34.	M/s. Chetan Industry Ltd., Gram Urla, Raipur
35.	M/s B.K. Rolling Mills Pvt. Ltd., Sarora, Raipur
36.	M/s Ramesh Steel Industries (Unit-II), Tatibandh, Raipur
37.	M/s Divya Strips & Profiles Pvt. Ltd., Urla, Raipur
38.	M/s Sai Steels, Urla, Raipur
39.	M/s A.S. Ispat Udyog, Jarway, Hirapur, Raipur
40.	M/s H.S.R. Re-Rollers Pvt. Ltd., Urla, Raipur
41.	M/s Shiv Shakti Rolling Mill, Sondongari, Raipur
42.	M/s Super Ispat Raipur Pvt. Ltd., Sarora, Raipur
43.	M/s Seth Banshidhar Kedia Steel Industries, Urla, Raipur
44.	M/s Shri Ram Steel, Chandnideeh, Raipur
45.	M/s Kisan Steel Rolling Mill, Urla, Raipur
46.	M/s Amrit Steel Rolling Mill, Urla, Raipur
47.	M/s Murli Rolling Mill, Sarora, Urla, Raipur
48.	M/s R.S. Steels Udyog, Urla, Raipur
49.	M/s Shri Krishna Udyog, Bhanpuri, Raipur
50.	M/s Venkteshwar Strips Pvt. Ltd., Urla, Raipur
51.	M/s Sindh Ispat, Rawabhata, Raipur
52.	M/s Vandana Rolling Mill, Urla, Raipur
53.	M/s Iskon Strips Pvt. Ltd., Guma, Raipur
54.	M/s A.C. Steels, Urla, Raipur
55.	M/s R. Narayan Steel Industries, Urla, Raipur
56.	M/s Ashirwad Ispat Udyog, Urla, Raipur
57.	M/s G & G Ispat Pvt. Ltd., Siltara, Raipur
58.	M/s R.K. Organic & Chemicals, Gondwara, Raipur
59.	M/s Indus Smelters Ltd., Urla, Raipur
60.	M/s Abir Steel Rolling Mill Pvt. Ltd., Urla, Raipur
61.	M/s R.B. Strips Pvt. Ltd., Urla, Raipur
62.	M/s Shri Sudrashan Ispat Pvt. Ltd., Urla, Raipur
63.	M/s Shri Krishna Steels (Unit-II), Chandnideeh, Raipur
64.	M/s R.K. Structures Pvt. Ltd., Sondongari, Raipur
65.	M/s G.P. Ispat Pvt. Ltd., Urla, Raipur
66.	M/s Surya Ispat, Urla, Raipur
67.	M/s Nandan Steels & Power Ltd., Sondra, Raipur
68.	M/s Khyati Ispat Pvt. Ltd., Jarway, Hirapur Raipur
69.	M/s Shri Giriraj Structures Pvt. Ltd., Urla, Raipur
70.	M/s Balaji Structures India Pvt. Ltd., Tatibandh, Raipur
71.	M/s Ganpati Ispat, Urla, Raipur
72.	M/s Gaurav Krishna Ispat Pvt. Ltd., Sarora, Urla, Raipur
73.	M/s Sunmarg Steel Pvt. Ltd., Gondwara, Raipur
74.	M/s Raipur Industrial Steel Company, Urla, Raipur
75.	M/s Ganpati Udyog, Gondwara, Raipur
76.	M/s Jaiswal Strips Ltd., Sondongari, Raipur
77.	M/s Kisan Mechanical Works, Urla, Raipur
78.	M/s Shri Kishan Rolling Mill, Urla, Raipur
79.	M/s Sarvottam Ispat, Rawabhata, Raipur
80.	M/s Alankar Steel Pvt. Ltd., Tatibandh, Raipur
81.	M/s Shri Krishna Iron Strips & Tubes Pvt. Ltd., Urla, Raipur
82.	M/s J.J. Re-Rollers, Gogaon, Sarora, Raipur
83.	M/s Ankit Steel, Gondwara, Raipur
84.	M/s Trimurti Re-Rollers Pvt. Ltd., Siltara, Raipur
85.	M/s Subhash Ispat Ltd., Siltara, Raipur

86.	M/s Hanuman Loha Pvt. Ltd., Urla, Raipur
87.	M/s Indian Ispat Works Pvt. Ltd., Rawabhata, Raipur
88.	M/s Agrawal Round Rolling Mills Ltd., Tatibandh, Raipur
89.	M/s A.V. Steels Pvt. Ltd., Urla, Raipur
90.	M/s Avinash Ispat Pvt. Ltd., Urla, Raipur
91.	M/s Radha Krishna Steel, Tatibandh, Raipur
92.	M/s Agrawal Steel Re-Rollers, Urla, Raipur
93.	M/s Sunil Steel, Urla, Raipur
94.	M/s Vivek Ispat, I/A Urla, Raipur
95.	M/s Laxmi Krupa Isapt Pvt. Ltd., Urla, Raipur
96.	M/s Shivam Steel Corporation, Sankra, Raipur
97.	M/s Kranti Steels Pvt. Ltd., Urla, Raipur
98.	M/s Baba Sitaram Ispat, Urla, Raipur
99.	M/s Albright Steel Industries Ltd., Rawabhata, Raipur
100.	M/s Hira Steel, Rawabhata, Raipur
101.	M/s Prakash Industries Pvt. Ltd., Sondongari, Raipur
102.	M/s Mahamaya Ispat Pvt. Ltd., Sarora, Urla, Raipur
103.	M/s Vandana Ispat Ltd., Sarora, Urla Raipur
104.	M/s Sourabh Rolling Mill Pvt. Ltd., Kanhera, Achholi, Raipur
105.	M/s Adinath Steel, Urla, Raipur
106.	M/s Ganpati Industrial Pvt. Ltd., Urla, Raipur
107.	M/s. Agrawal Rolling Mills Ltd., G. E. Road, Tatibandh Raipur
108.	M/s.Lingraj Steel and Power Pvt. Ltd, Industrial Area, Near Urla , Raipur
109.	M/s. Pankaj Ispsat Pvt. Ltd., Ring Road No.2, Gogaon Raipur
110.	M/s. Kanha Steel, Plot no. 46/5,6,7,8 Industrial Area ,Bhanpuri Raipur
111.	M/s. J.K. International track Pvt. Ltd, Beergaon Dharsiva , Raipur
112.	M/s.Jai Ambe Ispat Pvt. Ltd., Gram Sarora Urla, Raipur
113.	M/s. Riza Steel and Power Pvt. Ltd., Gram Bana, Raipur
114.	M/s. Shreenivasa Maruti Steel Pvt. Ltd., Gram Tenduwa, Raipur
115.	M/s.Godawari Re-rollers, Plot no. 54 and 55 Phase -2 Siltara , Raipur
116.	M/s. Ishwar Ispat Industries Pvt. Ltd., Plot No.168 Sector-C Industrial Area, Raipur
117.	M/s. Sapna Steel, Industrial Area Urla, Gram Sarora, Raipur
118.	M/s. Shree Shyam Rolling Mill, Gram Achholi, near Bhavani Metals Pvt. Ltd Raipur
119.	M/s. Agrasen Re-rollers Pvt. Ltd., Plot No.200A, Industrial Area Urla, Raipur
120.	M/s. Agrawal Steel Rolling Mills Ltd., G. E. Road, Tatibandh Raipur
121.	M/s. Balaji Steel Industries, Industrial Area Urla, Raipur
122.	M/s. Kasmas casting India Pvt. Ltd., (Rolling mill division) Gram –Heerapur Jervaay, Tenduwa Road, Raipur
123.	M/s. Iron Industry, Plot No.94, Industrial Siltara Phase -2 Area ,Raipur
124.	M/s. Saini Re-rollers Ltd., Cycle Park, Industrial Area Siltara Phase -2 ,Raipur
125.	M/s. Salimar Ispat Industry, Plot no 34. Industrial Area Urukuwa, Raipur
126.	M/s. Amit Strips, Gram –Heerapur Jervaay, Sondongri road,Raipur
127.	M/s. Kasmas Ispat Pvt. Ltd., Plot No.149/150, Industrial Area Urla, Raipur
128.	M/s. Navdurga Ispat Pvt. Ltd., Plot no. 435 A Sector C, Industrial Area Urla, Raipur
129.	M/s. Prakash Industries Ltd., (Rolling Mill Division), Ring road No.2, Gondwara, Raipur
130.	M/s. Shaktipunj Ispat Pvt. Ltd., Gram- Pathradih Achholi Road, Urla, Raipur
131.	M/s. Chhatisgarh Ispat Industry, Ring road No.2 Sondongari Raipur
132.	M/s.U.P. Rolling Mill, Industrial Area Sondongari , Ring Road No. 2, Raipur
133.	M/s. Satish Steel Industry, Ring road no. 2, Industrial Area Sondongari Raipur
134.	M/s. Shivam Structures and Steel Rolling Mill Pvt. Ltd., Gram Achholi Urla-

	Kanhera Road, Raipur
135.	M/s. The Raipur Industry Steel Company, Plot No. 631/632, Industrial Area Urla, Raipur
136.	M/s.Corporate Ispat Alloys Ltd., (previous name Rajendra Steel Ltd) Siltara Growth Centre, Raipur
137.	M/s. Raghunath Ispat, Gogaon ,Raipur
138.	M/s. Vinayak Ispat Industry, Industrial Area Rawabhata, Raipur
139.	M/s Raghupati Ispat, Gogaon, Raipur
140.	M/s. Venkteshwar Ispat, Urla, Raipur
141.	M/s. Sanjay Ispat, Rawabhata, Raipur
142.	M/s.Unique Structures and Towers Ltd., Urla, Raipur
142.	M/s. Amarnath Ispat, Tenduwa, Raipur
143.	M/s. Dadu Steel, Girond, Raipur
144.	M/s.Vishnupriya Ispat, Guma, Raipur
145.	M/s. Prime Ispat, Bana, Raipur
146.	M/s. Geeta Steel, Achholi, Raipur
147.	M/s.Trimurti Rolling Mill, Siltara, Raipur
148.	M/s. Mahamaya Rolling Mill, Tatibandh, Raipur
149.	M/s.Ma Kudargari Steel Pvt. Ltd., Gram Sarora, Ring road No.2 Raipur
150.	M/s. U.K Steel, Gram Sarora Urla, Raipur

(Source: CECB, Raipur)

Table B.2.4: List of Induction Furnace Units in Raipur Region

Sr. No.	Name of Industry
	Silatara Industrial Area
1.	M/s Shubh Labh Ispat Pvt. Ltd., Siltara, Phase-II, Raipur
2.	M/s Mahamaya Ispat, Urla, Raipur
3.	M/s M.J. Steel Pvt. Ltd., Siltara, Phase-II, Raipur
4.	M/s Hanuman Ispat Pvt. Ltd., Village Sondra, Siltara Phase-II, Raipur
5.	M/s Shri Shyam Ingot & Casting Pvt. Ltd., Phase - II, Siltara, Raipur
6.	M/s Shri Shyam Iron & Power Pvt. Ltd., Siltara, Raipur
7.	M/s Shri Bajrangbali Ingot & Steels Pvt. Ltd., Siltara, Phase-II, Raipur
8.	M/s S.R. Ingots Pvt. Ltd., Industrial Area Siltara, Raipur
9.	M/s Kailash Castings Pvt. Ltd., Siltara, Raipur
10.	M/s Jorawar Sponge & Engineering Industries Pvt. Ltd., Siltara, Raipur
11.	M/s Ispat India, Siltara, Raipur
	Urla Industrial Area
12.	M/s Birmiwal Steel Pvt. Ltd., Sarora, Urla, Raipur
13.	M/s Indus Smelters Ltd., Urla, Raipur
14.	M/s Agrawal Structure Mills Pvt. Ltd., Urla, Raipur
15.	M/s Bhawani Casting, Urla, Raipur
16.	M/s Ganpati Ispat, Urla, Raipur
17.	M/s Hightech Abrasive Pvt. Ltd., Urla, Raipur
18.	M/s Steel Abrasive Industries Ltd., Urla, Raipur
19.	M/s Prem Polymers (Induction Fur Div), Urla, Raipur
20.	M/s Ganpati Industrial Pvt. Ltd., (Induction Furnace Division), Urla, Raipur
21.	M/s Seth Banshidhar Kedia Steel Industries (IF Division), Urla, Raipur
22.	M/s A.C. Steels, Urla, Raipur
23.	M/s Gaurav Krishna Ispat Pvt. Ltd., Urla, Raipur
24.	M/s Krishna Iron Strips & Tubes Pvt. Ltd., Urla, Raipur
25.	M/s A.V. Steels Pvt. Ltd., Urla, Raipur

26.	M/s Harkat Agricultures Equipments Pvt. Ltd., Urla, Raipur
27.	M/s Ashok Ispat, Urla, Raipur
28.	M/s Duro Cast Industries, Urla, Raipur
29.	M/s Goyal Pipes Pvt. Ltd., Urla, Raipur
30.	M/s Sunil Steel, Urla, Raipur
31.	M/s Vandana Ispat Ltd., Sarora, Urla Raipur
	Tenduwa & Sarora Industrial Area
32.	M/s Amarnath Ispat, Village Tendua, Raipur
33.	M/s Cosmos Casting India Ltd., Tendua Road, Hirapur Raipur
34.	M/s Ma Kudargadi Steel Pvt. Ltd., Village Tendua, Hirapur Raipur
35.	M/s Birmiwal Steel Pvt. Ltd., Sarora, Urla Raipur
36.	M/s N.S. Ispat India Pvt. Ltd., Sarora, Raipur
37.	M/s Vandana Ispat Ltd., Sarora, Urla Raipur
38.	M/s Super Steel (Induction Furnace Div), Ring Road No. 2, Saroa, Raipur
39.	M/s Mahendra Strips Pvt. Ltd., Sarora, Raipur
40.	M/s Ma Kudargadi Steel Pvt. Ltd., Village Tendua, Hirapur Raipur
41.	M/s Amarnath Ispat, Village Tendua, Raipur
42.	M/s Om Kiran Ispat Udyog, Village Guma, Hirapur Raipur
	Other Industrial Areas
43.	M/s Indian Ispat Works Pvt. Ltd., Rawabhata, Raipur
44.	M/s Jai Ambey Metal Works Pvt. Ltd., Rawabhata, Raipur
45.	M/s Garuda Ispat Pvt. Ltd., Village Sondra, Raipur
46.	M/s Mahalaxmi Steel Industries, Gogaon, Raipur
47.	M/s Sarveshwar Alloys Pvt. Ltd., Gogaon, Raipur
48.	M/s Maruti Ferrous Pvt. Ltd., Village Sondra, Raipur
49.	M/s Sunmarg Ispat Pvt. Ltd., Gondwara, Raipur
50.	M/s Bajrang Metalics & Power Ltd., Gondwara, Raipur
51.	M/s Chhattisgarh Ferro Traders, Gondwara, Raipur
52.	M/s Alankar Steel Pvt. Ltd., Tatibandh, Raipur
53.	M/s Agrawal Round Rolling Mills Ltd., Tatibandh, Raipur
54.	M/s Balaji Structurals India Pvt. Ltd., Tatibandh, Raipur
55.	M/s Dadu Steels & Power Ltd., Village Giroud, Raipur
56.	M/s Sterling Strips Ltd., Bhanpuri, Raipur
57.	M/s Orissa Concrete & Alloyed Industry Ltd., Bhanpuri, Raipur
58.	M/s Gold Star Steels Pvt. Ltd., Bhanpuri, Raipur
59.	M/s Prayash Steel, Village Charouda, Tulsi Raipur
60.	M/s Ras Buildcon & Steels Pvt. Ltd., Village Jalso, Tilda Raipur
61.	M/s Kwality Foundry Industries, Amaseoni, Raipur
62.	M/s Sourabh Rolling Mill Pvt. Ltd., Kanhera, Achholi, Raipur

(Source: CECB, Raipur)

Abbreviations and Acronyms

AAQM	Ambient Air Quality Monitoring
AAQ	Ambient Air Quality
AQM	Air Quality Monitoring
AFBC	Atmospheric Fluidized Bed Combustion
BALCO	Bharat Aluminum Company Limited
BDL	Below Detectable Limit
BF Gas	Blast Furnace Gas
BIS	Bureau Of Indian Standards
°C	Degree Celsius
Ca^{+}	Calcium ion
Cd	Cadmium
CECB	Chhattisgarh Environment Conservation Board
Cl^{-}	Chloride ion
CO	Carbon Monoxide
Co	Cobalt
CPCB	Central Pollution Control Board
CPP	Captive Power Plant
Cr	Crore
Cr	Chromium
CSIDC	Chhattisgarh State Industrial Development Corporation
Cu	Copper
DRI	Direct Reduced Iron
ESP	Electro-Static-Precipitator
F^{-}	Fluoride ion
FA	Ferro Alloy
FBC	Fluidized Bed Combustion
FC	Fixed Carbon
Fe	Iron
FO	Furnace Oil
GCV	Gross Calorific Value
GLCs	Ground Level Concentrations
ha	Hectares