A

Paper

on

Plant Location Specific Emission Standards

CONTENTS

1. Introduction

Hon'ble Minister of State (IC) Power & NRE chaired a meeting on 21.01.2020 to review the progress of installation of FGDs in Thermal Power Plants at Shram Shakti Bhawan, New Delhi. The para 4.5 of the above MOM is reproduced as below:

"It was noted that periodicity of pollutants monitoring was not specified by MoEF&CC and there is a need to have different emissions norms for different ambient conditions. CEA shall submit a paper to suggest periodicity of pollutants monitoring as well as plant location specific emission standards with suitable basis to be taken up with MOEF&CC. MOP shall take up the matter with MOEF&CC …………...."

As per the minutes of meeting, CEA is required to submit a paper suggesting the plant location specific emission standards with suitable basis to MOP for further taking up with MoEF&CC.

So far thermal power plants were required to meet the particulate emission norms only and there was no regulation for SO_2, NOx and Mercury emissions. Standards were specified only for the chimney height to ensure the flue gas pollutants were dispersed. On December 7, 2015, the Ministry of Environment, Forest and Climate Change (MoEF & CC) introduced stricter environmental standards for coal-based TPPs (Table-1) under the Environment (Protection) Act, 1986.

Table 1 New Environmental Norms, December 2015

Date of Installation	PM	SO2	NOx	Mercury (Hg)
Before December 2003	100mg/Nm^3	600mg/Nm^3 < 500MW 200mg/Nm3 >= 500MW	600 mg/Nm^3	0.03 mg/Nm^3 for >=500MW
January 2004 to December 2016	50mg/Nm^3	600mg/Nm^3 < 500MW 200mg/Nm3 >= 500MW	300 mg/Nm^3	0.03 mg/Nm^3
January 2017 onwards	30mg/Nm^3	100 mg/Nm^3	100 mg/Nm^3	0.03 mg/Nm^3

2. Ambient Air Quality (AAQ) Data

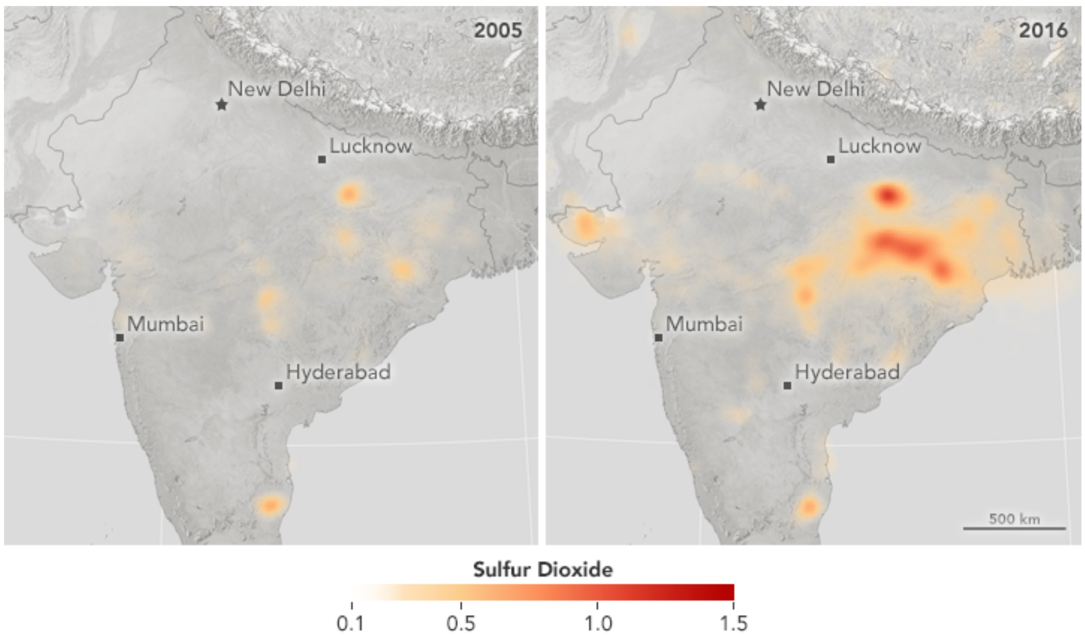
The latest ambient air quality (SO_2, NO_2, PM_{10}, $PM_{2.5}$) data monitored for the 745 stations located cross the breadth of country has been published for the year 2018 by CPCB. It is seen from the ambient air quality data that the concentration level of PM is on the higher side in comparison to the SO_2/NOx emission levels (Annexure I). The data is available for 24 hr. average (min./max.) and annual average for the above mentioned sub-indices. Even if, only 24 hr. average (max.) data is analysed, it can be seen that the SO_2 ground based levels across the country are mostly within a range of 0-40μg/m^3 which is good as per the MoEF&CC standards (Annexure I). However, the major cause of concern is the PM_{10}, $PM_{2.5}$ levels which are relatively very high. This suggests that high particulate matter ($PM_{2.5}$/PM_{10}) levels is a country wide phenomenon and the particulate matter contribution by the thermal power plants have to be controlled to the new emission standards (Dec 2015).

However, power plants located in an area, where quality of air is very good in terms of SO_2, can be exempted from installation of additional equipment to control SO_2 emission from stack. A large number of thermal power stations are located in remote locations away from towns with little habitations around. Thermal power plants located in remote locations, ambient air quality (AQI) can be made as the guiding factor for formulating emission control. This may avoid installation of additional emission control equipment without compromising the air quality. There should be a baseline air pollution level for SO_2/NOx/$PM_{2.5}$/PM_{10} which is maintained across the country. It will ensure the baseline air quality everywhere and norms will be relatively stringent in areas where air quality is critically poor and relatively relaxed where air quality is not so critical.

Thus the SO2 norms, which is required to be implemented for critically polluted area, may not be applicable for area where quality of air is good. Implementation of same norm across the country will not ensure uniform air quality as the prevailing air quality is supposedly diverse in different geographical areas.

The satellite imagery (Fig 1) gives a bird's eye view of the regions (2016) where high concentration of SO_2 is occurring in the atmosphere. It broadly isolates the problem region which need immediate rectification. The locations can be identified as small

Figure 1 Satellite imagery of SO_2 Emissions observed over India (courtesy



NASA)

clusters in the states of Odisha, Jharkhand, Chhattisgarh, Maharashtra, Tamil Nadu and Gujarat. As the satellite image shows the concentration of SO_2 at certain height, the measurement of ground level SO_2 in the same area can play an important role.

In an attempt to explore such a feasibility, the 24hr avg.(max) SO_2 ground based measured levels (CPCB, 2018 data) were categorized into 5 distinct levels:

i. Level I: >40 μg/m^3,
ii. Level II: 31-40 μg/m^3,
iii. Level III: 21-30 μg/m^3,
iv. Level IV: 11-20 μg/m^3 and,
v. Level V: 0-10μg/m^3.

It can be seen that the gradation levels adopted as above are more or less correlating with the satellite image data (refer Annexure I, level). The gradation would be helpful in prioritizing the installation of emission control equipment in a phased manner.

To achieve tangible results, the SO_2 emission control equipment in the thermal power plants located in **level I** regions should have to be installed on priority basis. The regions as identified under **level II** can be covered subsequently under the next phases. Presently no action is required for the plant located in region under **level III/IV/V** as the SO_2 present in ambient air of this area is very less and as per CPCB the quality of air is good in regards to SO_2 as shown in the table below:

Table 2 Various SO_2 limit values as per Air Quality Index (AQI), MOEFF&CC

Concentration Range (µg/m3)	**Good**	**Satisfactory**	**Moderately polluted**	**Poor**	**Very poor**	**Severe**
SO_2	0-40	41-80	81-380	381-800	801-1600	1600+

MoEF&CC has adopted air quality standards for the country (NAAQS) and also defined the index (AQI) for categorizing the ambient air quality ("good" to "severe") based on the SO2 concentration levels. The real time data from the extensive grid of ambient air quality monitoring stations located across the country and elsewhere (thermal power plants) can be indicative of the dispersion taking place over geographical areas and in different weather conditions which can be utilized for the future course correction. The reliability and availability of data from these monitoring stations is of prime importance, on the basis of which, important decision can be taken.

3. Thermal Power Plant Emissions

The thermal power plant emissions have both local and global impact. Global impact is mostly due to the production of greenhouse gases CO_2 and locally it contributes large quantity of bottom ash, fly ash (PM) and some emissions of SO_2/ NOx. The greenhouse gas emission levels are being taken care of by reducing the emission intensity of GDP 30% to 35% by year 2030 from the 2015 levels. This is planned to achieve by having 40% of the installed capacity from non-fossil fuel based plants in year 2030.

The present stack height of thermal power plant is designed to take care of the dispersion of SO_2/NOx emissions from thermal power plants and its impact can be seen from the ambient air quality data of various thermal power plants. The ambient air quality measurements are ground based.

For ascertaining dispersion of emissions from the stack, the satellite imagery and the modelling studies are useful tools. The satellite imagery (Figure 1) indicates the changes in the vertical column density levels of atmospheric SO_2 in a decade from year 2005 to 2016. It shows that the SO_2 hot spots (2016) are concentrated in small clusters in the states of Odisha, Jharkhand, Chhattisgarh, Maharashtra, Tamil Nadu and Gujarat having large installed capacities of thermal power plant, which would need to be effectively taken care off on priority basis. The long-range transport of thermal plant emissions (SO_2/NOx/PM) from the stacks, atmospheric drift/ dispersion, and their period life shall have to be analyzed exhaustively to find their cumulative influence on the surrounding areas, which shall in turn identify the location specific thermal plants which need immediate attention. Therefore, the response to different regions for the effective control of emissions can be different.

In one of the air quality dispersion modelling study conducted recently by **IIT Kanpur** for the impact of Talwandi Sabo thermal power plant (District Mansa, Punjab) emissions to the ambient air quality has shown that SO_2 levels of about

45.9µg/m³ at the plant drop significantly to 1µg/m³ at a distance of 40 km (Copy enclosed). Thus, beyond 40 km the impact of SO_2 becomes insignificant. Similar trend is seen in the case of NOx.

In June 2020, TPRM division, CEA had sent the request to all the thermal generating companies to furnish online ambient air quality data (PM/SO_2/NOx) at least for one year collected from the AAQ monitoring stations located in their respective plants. Since then, the generating companies/stations which have responded are as mentioned in Annexure II. The data was analyzed for an installed capacity of 35,708 MW and has been tabulated as below.

Accordingly, thermal power plants are categorized in the table-3 considering the maximum value of SO_2 in the vicinity of thermal power plant and similarly in table-4 considering average value of SO_2 in the vicinity of power plant.

Table 3 SO_2 Levels (max.) in the vicinity of Thermal Power Plants

SO_2 Level (µg/m³)	**0-10**	**11-15**	**16-20**	**21-25**	**26-30**	**31-35**	**36-40**	**>40**
Thermal Capacity, MW (% of total)	6,900 (19.3%)	6,700 (18.8%)	2,980 (8.3%)	2,220 (6.2%)	8,250 (23.1%)	-	1,598 (4.5%)	7,060 (19.8%)

Table 4 SO_2 Levels (avg.) in the vicinity of Thermal Power Plants

SO_2 Level (µg/m³)	**0-10**	**11-15**	**16-20**	**21-25**	**26-30**	**31-35**	**36-40**	**>40**
Thermal Capacity, MW (% of total)	11,020 (30.9%)	9,030 (25.3%)	8,860 (25.8%)	290 (0.8%)	-	2,520 (7.1%)	2,528 (7.1%)	1,460 (4.1%)

Thus, it may be stated that the immediate action has to be taken for thermal capacity of 7060 MW and next phase for 1598 MW as per Table-3. But as per Table-4 these thermal capacities are 1460 MW and 5048 MW for immediate action and next phase respectively.

4. Approach according to AAQ

The installation of the emission control equipment in large fleet of thermal plants should be carried in graded manner, starting with those located near most affected cities/areas where ambient SO_2 level is more than 40µg/m^3 (level -I) and in next phase may be after 1 year of commissioning of 1st phase (observing the effectiveness of the control equipment), in plants located in areas where ambient SO_2 level is more than 30µg/m^3 (level-II). Presently thermal plants located in the area where ambient SO_2 level is less than 30µg/m^3 (level-III, VI & V) need not to take any corrective measures. The list of power plant according to their location (level of SO_2 in ambient air) is given at Annexure II. The ambient air quality is divided into five regions according to the presence of SO_2 level and the capacity of thermal power plants under various level (on the basis of received data only) has been identified (Table 5).

Table 5 Thermal Capacity based on Ambient Air Quality SO_2 Levels

Region	**Ambient Air SO_2 Concentration Levels**	**Total Capacity (MW)**
1	Level-I (>40µg/m^3)	1,460
2	Level-II (>30µg/m^3 &≤40µg/m^3)	5,048
3	Level-III (>20µg/m^3 &≤30µg/m^3)	290
4	Level-IV (>10µg/m^3 &≤20µg/m^3)	17,890
5	Level-V (>0µg/m^3 &≤10µg/m^3)	11,020

The phasing will help in understanding the impact of these control equipment on their effectiveness and give a time for future course correction. There are different technologies available to control the flue gas emissions and their suitability needs to be ascertained in the Indian conditions. Installing the pollution control equipment in one go in all the thermal power stations may not be the best option to adopt. The implementation of emission control measures in all power plants simultaneously will inevitably lead to the following which is not in the interest of the country;

i) Lack of time for developing indigenous manufacturing facility,

ii) Resorting to import of equipment thus creating market for mainly foreign companies,

iii) Huge investment of over one lakh crore required. Majority of which will lead to the foreign exchange drain for outsourcing of new technology, skilled manpower and equipment as there is lack of time to develop the facility indigenously.

5. International Emission Norms

The new standards delimited SO_2, NOx, and Mercury (Hg) emissions for the first time and the existing limits on PM emissions were made stringent (Table 1). MoEF&CC has set a deadline to comply with the new standards by the end of 2019 for national capital region, 2021 for critical areas and 2022 for all other thermal units.

Table 6 Emission limit values for Coal fired power plants, China

Pollutants	Location	Emission Limits, mg/m3
PM	All areas	30
	Key Region	20
SO_2	New	100/200
	Existing	200/400
	Key Region	50
NOx	All areas	100/200
	Key Region	100

China began to install desulfurization equipment's from 1996 and in two decades' time by 2015 its 83% of the total thermal capacity was equipped with emission control equipment's. Emission norms are location specific in some of the countries (China, Australia) which have substantial coal fired power generation. Key areas in China which includes Beijing City, Tianjin City, Hebei Province, Wuhan City and many more areas have stricter emission standards over the baseline emission levels as shown in the table. Similarly, in Australia, the emission levels for coal fired power plants varies from region to region is shown in the table below.

Table 7 Region wise Emission standards of Australia

Region	PM		SO_2		No_x	
	Existing	New	Existing	New	Existing	New
$Australia_{NHMRC}$	80 mg/m^3		200 mg/m^3		800[1] mg/m^3	
$Australia_{SOUTH}$	250[2]mg/m^3		100[3]mg/m^3		700[4] mg/m^3	
$Australia_{TASMANIA}$	100 mg/m^3		100[3]mg/m^3		500[5] mg/m^3 800[6] mg/m^3	
$Australia_{VICTORIA}$	500 mg/m^3	250 mg/m^3	200[7]mg/m^3	200[7]mg/m^3	1000[8]mg/m^3	700[4] mg/m^3

1 Power Generating Boilers >30MW
2 Plant Size >100MJ/h
3 Sulphuric acid mist and SO2
4 Plant Size >250MWe
5 Plant Size <30MWe
6 Plant Size >30MWe
7 SOx as SO_3
8 Plant Size > 150,000MJ/h

Courtesy: Xing Zhang, Emission Standards and Control of PM2.5 from Coal-fired Power Plant, July 2016, IEA Clean Coal Centre UK

Based on actual ground measurements and detailed dispersion studies coal-fired power plants which are found to affect the ambient air quality of cities, towns and areas where

cluster of thermal plants is located should be subjected to the stringent emission standards, similar in line to those adopted in the other countries.

6. Recommendations

There are two ways to go forward to mitigate the challenges faced by the thermal power sector by the new emission norms and both (as mentioned below) can be adopted for improving the situation.

i. Our target should be to maintain uniform ambient air quality across the country and not the uniform emission norms for thermal power plants. By implementing uniform emission norms of TPS which may in turn result in different air quality at different location. Same norms for thermal power plants located in critically polluted area and other area where air quality is already good doesn't look to be proper as additional costs are involved. Instead we should aim to maintain same air (good) quality throughout the country and accordingly it is proposed to implement FGD for the thermal power plants region-wise as given in the table below.

Table 8 Phasing of FGD Installation based on Ambient Air Quality SO_2 Levels

Region	**Ambient Air SO_2 Levels**	**Remarks**
1	Level-I (>40µg/m³)	FGD shall be installed immediately
2	Level-II (>30µg/m³ &≤40µg/m³)	FGD shall be installed in 2nd phase
3	Level-III (>20µg/m³ &≤30µg/m³)	FGD is not required at present
4	Level-IV (>10µg/m³ &≤20µg/m³)	FGD is not required at present
5	Level-V (>0µg/m³ &≤10µg/m³)	FGD is not required at present

a) In areas where the development is high, the atmospheric air quality is poor and is prone to serious atmospheric pollution problems, strict control of emissions shall be required in such key areas for TPS as categorised under Region 1.

b) In next phase may be after one year commissioning of 1st phase units, observing the effectiveness of installed equipment, to be implemented in the power plant which are located under Region 2

c) Presently no action is required for power plant those are situated under Region 3,4 & 5.

ii. There should be graded action plan for adopting new emission norms for TPS as proposed above rather than adopting a single deadline for large base of power plants across the country. An unworkable time schedule will create market scarcity leading to import, jacked up prices unnecessary burden on power utilities. Graded action plan will help in utilizing the resources in effective manner and it will help in fine tuning the technology for local conditions. If the process of emission control is completed in 10-15 years' time frame, and consider thermal power plants located in critically polluted areas in first phase, it will help in developing indigenous manufacturing base, skilled manpower in the country which shall take care of the local operating conditions.

Annexure I

AMBIENT AIR QUALITY MONITORING DATA FOR THE YEAR 2018

Maximum (24-hourly average)

State / UT	City / Town / Village	Location	SO_2 $\mu g/m^3$	NO_2 $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	Level
Andhra Pradesh	Anantapur	Kamala Nagar	11	54	179	102	IV
		APIIC, Zonal office, Industrial Estate	9	28	129		V
		Cancer Unit. G.G.Hsharada Nagar, JNTU Road	6	22	104		V
		D.No.6/5/545, Ram Nagar Colony	13	31	145		IV
	Chitoor	GNC Toll Gate Tirumala	22	92	157	77	III
		Near Nutrine Confectionery, Palamaner Road	12	69	200	62	IV
		Mining Office, Greamspet	6	20	165		V
		Sankar Foundary	7	29	92		V
	Eluru	Ashram Diagnostic Centre	6	27	85		V
		District Headquarters hospital	6	30	76		V
		M/s Laxmi Propylene Ltd., Plot.No. 25, Industrial Park, Satrampadu	6	30	76		V
		Somalingeswara nilayam D.N.7B-18-5, Thooru Veedhi, Eastern street, Paidichintaadu	6	30	71		V
	Guntur	Near Hindu College, Market Road	7	28	147		V
		A.P. Pollution Control Board, D.No.4-5-4/5C,4/3, Navabharath nagar, Ring Road	14	29	125		IV
		Distirct Industries Center office Buiding Autonagar	7	29	81		V
		Government General hospital	7	29	125		V
	Kadapa	Near ICL Industries, Yerragunta, YSR	8	28	103	43	V
		Devi Diabetes & Hormone Centre, 7 Roads	12	32	136		IV
		DIC Office,Kadapa	7	34	123		V
		RIMS	7	19	78		V
		Municipal Primary School	6	33	128		V
	Kakinada	Office Building Ramanayyapeta	15	52	179	110	IV
		Gram Panchayathi building, Surya rao peta	14	33	149		IV
		MEE/MEPMA building, Salipeta	16	32	195		IV
		Petrochemical Eng. Of JNTU Campus	12	25	160		IV
	Kurnool	Mourya Inn, Krishna Nagar	9	22	129	65	V
		APIIC Building Industrial estate, Kallur at IDA Bobbili Growth Center	9	27	129		V
		Rajvihar Circle	10	46	120		V
		Pump House, Venkataramana Colony	8	23	91		V
	Nellore	Venkatareddy Nagar, Vedayapalem	6	40	88	38	V
		D. No.15-471, James Garden, Venkata Ramapuram, Nellore, SPSR Nellore District	6	27	96		V
		Chandramouli nagar	6	26	79		V
		Dr.P.V. Rama chandra Reddy Hospital, Brindavnam	6	28	68		V
	Ongole	Near Court Center	6	27	101		V
		APIIC , Administrative Office, IGS	6	25	71		V
		Ongole Municipal Corporation	7	29	91		V
		Prakasam Milk Produce Compay	8	26	73		V
	Rajahmundry/ Rajamahendra varam	Staff Clud Building, A.P. Paper Mill	13	28	168	107	IV
		GAIL Administrative Office, A.V. Apparao Road	12	26	175		IV
		MCH Block ,District Hospital, Near Central Prison, Lalacheruvu Road	10	24	149		V
	Srikakulam	SAMKRG Pistons Quarters Bulding, Near IDA, Pydibhimavaram	16	30	344		IV
		District cooparative office at SKLM Old Bridge	14	28	218		IV
		Kushalapuram	12	25	93		IV
		Muncipal corporation Office, Old Bustand	15	36	249		IV
	Tirupati	Regional Science Centre, Chittoor Bypass	7	40	146	14	V
		Municipal Office	6	38	104		V
		APPCB-Regional Office	5	20	109		V
		S.V. Guest house	6	29	93		V
	Vijaywada	NTR Veterinary college of sciences, Gannavaram	5	21	86		V
		VR Siddhartha Engineering college , Kanuru	5	21	59		V
		APIIC,IALA, IDA, Kondaplli	5	22	84		V
		Benz Circle	6	66	105	48	V
		Autonagar	6	28	108	52	V
		Police Control Room	6	29	107	50	V
		A.P. Pollution Control Board, plot no. 41, Sri Kanakadurga Officers colony, Gurunank Road	6	27	105		V
		Gram Panchayat Office, Yenamalakuduru	7	29	106		V
		Indian Medical Association Hall,Eluru Road, Governorpet	7	31	109		V
	Vishakhapatnam	Industrial Estate, Marripalem	19	41	160	77	IV

		Panchayat Raj office, Mindi	25	39	236	161	III
		Police Barracks	20	73	230	159	IV
		INS-Virabahu, Naval Area	15	39	210	71	IV
		Seethammadhara	24	43	222	151	III
		Ganapuram Area	29	43	299	201	III
		Pedagantyada (V), Gajuwada (M)	22	33	181	122	III
		CWMP, RAMKY, Parawada	23	33	145	93	III
		MVP Raitu Bajar	19	35	214		IV
	Vizianagaram	APIIC Building at IDA Bobbili Growth Center	16	33	95		IV
		APIIC Building, VT Agraharam,Industrial area	17	36	85		IV
		Muncipal Kaspa High School	13	28	150		IV
Arunachal Pradesh	Itnagar	PCCF's Office Compound	13	18	287		IV
Assam	Naharlagun	APSPCB Office compound	9	7	211		V
	Bongaigaon	Oil India Ltd. PS-6, Chirang	29	43	184		III
		Barpara Office Building	26	39	150		III
	Daranga	BATAD, Sandoop Jhankar town of Bhutan, Baska	12	21	183		IV
	Dibrugarh	Dibrugarh Office Building	10	19	171		V
	Golaghat	Golaghat Office Building	9	19	136		V
	Guwahati	Head Office, Bamunimaidam	23	34	250	197	III
		Boragaon, IASST, Kamrup	16	25	252		IV
		Guwahati University, Kamrup	16	30	188		IV
		ITI Building, Gopinath Nagar	16	27	324		IV
		Khanapara, Central Dairy, Kamrup	20	28	222	98	IV
		Near Pragjyotish College, Santipur	17	27	305		IV
	Margherita	Coal India Office	9	18	109		V
	Nagaon	Water Resources Div., Christian Patty, Nagaon College	16	24	222		IV
	Nalbari	PWD Rural Div Office Complex, near Gordon Boy's GS School	15	29	180		IV
	North	Bazar Patti, North Lakhimpur Town	16	27	163		IV
	Silchar	Govt. Boys HS School, Janiganj	8	14	60		V
		RLO, Ithkola Market, Ghaniwala Road	9	12	60		V
	Sivasagar	Sibasagar Office Building	9	19	133		V
		Usha Lodge, near ONGCL Colony	11	26	183		IV
	Tezpur	Tezpur Office Building	13	24	198		IV
	Tinsukia	Digboi Carbon factory Campus, Borguri	9	21	144		V
		Shreepuria, Borguri	10	22	120		V
		Shivdham	9	18	147		V
Bihar	Begusarai	Begusarai	16	28	187	141	IV
	Darbhanga	Smt Baby Kumari, Ashok Hotel,Kadirabad Chowk	27	41	437		III
	Gaya	Godam Road, Raja Market	16	28	261		IV
	Muzaffarpur	BSPCB Regional Office, Bela Industrial Area, Bela	22	49	423	239	III
	Patna	Beltron Bhawan, Shastri Nagar	13	74	426		IV
		Gandhi Maidan, Auto Exhaust Test Centre	36	124	564		II
	Rajgir	Sujkund, Near Samuraji hotel	16	29	173		IV
	Sasaram	Takia,Ward no.2, Rhotas	16	30	215		IV
Chandigarh	Chandigarh	Modern Foods, Industrial Area	2	44	341	240	V
		Sector-17 C	2	48	292	190	V
		Punjab Engineering College, Sector- 12	2	41	399	275	V
		Sector-39, IMTECH	2	52	570	182	V
		Kaimbwala Village	2	33	263	178	V
Chattisgarh	Bilaspur	Regional Office, CECB Vyapar Vihar	9	19	72	38	V
	Durg- Bhillainagar	Visak Hostel, Sector-4	11	21	95		IV
		R.O., 5/32 Banglow Office Building	6	15	77		V
		M.P. Laghu Udyog Nigam	27	26	106		III
		CSIDC Industrial Growth Center, Borai	12	25	100		IV
	Korba	HIG 21,22.Near Ghantaghar, MP Extension	13	22	87	28	IV
		Pragati Nagar NTPC Colony, Jamnipali	24	32	115	22	III
	Raigarh	Regional Office, ECB, Raigarh			77	35	V
		Jindal Industrial Area,Punjipathra, Raigarh			95	56	V
	Raipur	New HIG-9, Hirapur/Housing Board Complex Kabir Nagar	17	26	91		IV
		M/S Wool Worth India Pvt. Ltd. Sarora	24	41	99		III
Dadra & Nagar Haveli	Baldevi (Dadra & Nagar Haveli)*	Baldevi Village, Athola, Dandul Faliya, Teh:Dadra & Nagar Haveli	24	52	130	46	III
	Silvassa	Khadoli Industrial Area, Khadoli	45	51	178	59	I
		Chetan Guest House, Near Post Office, Piperia, silvassa Char Rasta	45	43	171	59	I
Daman & Diu	Daman	Prima Plastic, Kadaiya Industrial Area, Kadaiya	40	45	157	59	II
		Mashal Chawk, Nani Daman	41	42	158	57	I
	Patlara (Daman)*	Makat Faliya/ Ambavadi, Patlara Village, Moti Daman Teh:Daman	34	29	140	45	II
Delhi	Delhi	N.Y. School, Sarojini Nagar, Delhi	26	179	345		III
		Janakpuri	44	135	1076	988	I
		Naraina Industrial Area, Delhi	31	174	416	341	II

		Nizamuddin	13	166	708	204	IV
		Pritampura	41	160	990	831	I
		Shahadra	31	124	699	365	II
		Shahzada Bagh	21	181	918		III
		Siri Fort	12	123	916	116	IV
		Town Hall, Ayurvedic Dispensary, Chandni Chowk, Delhi	22	190	400		III
Goa	Amona	Amona, Bicholim	10	18	98	31	V
	Assanora	Assanora Junction, Bardez	12	17	95	31	IV
	Bicholim	Bicholim	10	16	173	56	V
	Codli	Codli Tisk, Ponda, Sanguem	11	17	143	46	IV
	Cuncolim	Cuncolim	17	20	94	54	IV
	Curchorem	Curchorem, Sanvordem, Quepem	13	18	83	56	IV
	Honda	Honda Junction, Sattari	10	17	145	44	V
	Kundaim	Kundaim Industrial Estate	12	26	185	56	IV
	Mapusa	Mapusa town	20	23	206		IV
	Margao	Margao Town	9	17	94	30	V
	Mormugao	Fire Brigade Station, Port Trust	18	27	300	64	IV
	Panaji	Old GSPCB premises, Patto	20	25	149	19	IV
	Ponda	Ponda Town	11	19	257	84	IV
	Sanguem	Near Railway Station at Kalem, Sanguem	15	20	83	46	IV
	Tilamol	Quepem, Tilamol	12	22	141	71	IV
	Tuem	Tuem Industrial Estate	11	17	87	27	IV
	Usgao	Usgao Plae, Junction, Ponda	11	17	102	32	IV
	Vasco	Fuse Call Office, Mormugao	17	79	304	98	IV
Gujarat	Ahmedabad	Naroda, G.I.D.C., Ahmadabad	32	46	334	96	II
		Cadilla Bridge Narol	49	66	419	128	I
		Bhagavathi Estate, Keval Kanta Road, Rakhiyal	38	78	408	134	II
		Reliable Products, 61/62 Ilaben estate,PiranaDump Site,Narol (previous Dyno Wash)	32	52	504	143	II
		L.D. Engg. College	33	70	329	185	II
		Shardaben Hospital, Saraspur	32	59	378	106	II
		R.C. Technical High School, Mirzapur	28	53	408	112	III
		AZL Behrampura, Ahmadabad	33	70	327	97	II
		Sola L.T. Chanakyapuri Pumping Station	37	74	374	109	II
	Anklesvar	Rallis India Ltd.	31	41	218	75	II
		Durga Traders, Bhavanafarm Society	28	56	245	75	III
	Jamnagar	Fisheries Office	35	59	272	107	II
	Rajkot	Nr. Sardhara Industrial Corporation	38	59	411	112	II
		GPCB Regional Offce	37	80	326	112	II
	Surat	S.V.R. Engg. College	49	57	150	59	I
		B.R.C. High School, Udhna	65	87	401	126	I
		Near Air India Office	50	59	318	96	I
	Vadodara	GPCB Office, Geri Vasahat	35	46	249	84	II
		Sterling Gelatin Guest House, Vill-Karakhadi Padia	33	46	228	82	II
		Dandia Bazaar	42	60	326	102	I
		CETP Nandesari	43	54	391	108	I
		Lubrizol	65	85	322	100	I
	Vapi	GEB, IIIrd Phase, GIDC	38	58	317	96	II
		Vapi Nagar Palika, Vapi	29	38	296	98	III
Haryana	Hissar	Urban Estate - II	14	12	306		IV
Himachal Pradesh	Baddi	Industry Department Office Building	3	55	644		V
		AHC barotiwala	3	56	463		V
		Housing Board	3	51	659		V
	Damtal	Regional Office	2	16	589	148	V
		Old Road	2	24	281	95	V
	Dharamshala	Kotwali Bazar Dharamshala	2	9	66	54	V
		Daari, Dharamshala	2	19	192	79	V
	Gulaba	Behind green tax barrier	2	11	72		V
	Kala Amb	Kala Amb Industrial Area	4	18	524	87	V
		Kala Amb Town/Trilokpur	10	19	178	79	V
	Manali	Nehru Park, Manali, Kullu	5	29	207	75	V
		HPSPCB, Hadimba Road, Manali, Kullu	3	18	121	48	V
	Marhi	Behind Police check post	2	5	42		V
	Nalagarh	Municipal Council	2	52	520		V
	Paonta Sahib	Paonta Sahib	10	18	435	103	V
		Gondhpur Industrial Area	5	18	690	113	V
	Parwanoo	Regional Office, Sector- 4	3	32	294	117	V
		Asst. Commissioner Building Sector I	3	6	112	19	V
	Shimla	Bus Stand, Winterfield	8	40	168	65	V
	Sunder Nagar	HPSPCB, BBMB Colony, Mandi	2	20	321	162	V
		Muncipal Council, NH-21, Mandi	2	28	464	151	V

	Una	Regional Office, Una	2	6	556		V
		DIC Building, Mehatpur, Una	2	7	84		V
	Vashisht	Behind pollution check barrier, Bhang	3	13	90		V
Jammu & Kashmir	Jammu	Regional Office, Jammu	7	25	367	77	V
		M.A. Stadium, Jewel Chowk	8	24	291	79	V
		Bari Brahamana Industrial Area	7	24	283	63	V
	Pulwama	Khrew			170		V
	Srinagar	SPCB Office Campus, Srinagar			162		V
		Khonmoh			205		V
		Lasjan, Budgam			820		V
Jharkhand	Barajamda	Barajamda U.M. Office	20	63	104		IV
	Dhanbad	R.O. Dhanbad	19	47	358		IV
		EMTI, Bastacola	19	53	465		IV
		CGM Office, Kusunda	26	59	481		III
	Jamshedpur	Bistupur Vehical Testing Centre	49	59	190		I
		Golmuri Vehicle Testing Centre	43	56	186		I
	Jharia	M.A.D.A.	18	45	498		IV
	Ranchi	Albert Ekka Chowk, Main Road	21	39	147		III
	Saraikela	RO Building, Adityapur	46	56	196		I
	Sindri	BIT / PDIL	22	45	214		III
Karnataka	Bagalkote	Bagalkote KSPCB Office Premises	2	34	106	78	V
	Bangalore	Graphite India, White Field Road	3	40	270	70	V
		AMCO Batteries, Mysore Road	4	41	162	72	V
		KHB Industrial Area, Yelahanka	3	40	254		V
		Peenya Industrial Area	3	41	158	66	V
		Victoria hospital	5	37	129		V
		Yeshwanthpura police station	4	40	243	91	V
		Jnanabharathi, Bangalore University	10	23	65		V
		TERI office, Vital Medi healthcare Pvt Ltd	3	39	175	69	V
	Belgaum	Karnataka SPCB Office Building	2	23	325	82	V
	Bidar	KSPCB Office Premises	3	32	147	76	V
	Bijapur	KSPCB Office Premises	2	21	185	75	V
	Chitradurga	KSPCB Office Premises	17	12	354		IV
	Devanagere	Regional Office building, KSPCB	10	12	83	45	V
		HPF Intakewell, Kumarapattnam	24	11	70	33	III
	Gulburga	Government Hospital	5	41	154	90	V
	Hassan	KSRTC bus stand building	5	23	47	39	V
	Hubli-Dharwad	Lakkamanahalli Industrial Area, Dharwad	7	29	87	36	V
		Rani Chennamma Circle, Hubli	8	30	106	41	V
	Kolar	KSPCB Office Premises, Kolar	2	39	148	58	V
	Mandya	KSPCB Building, Bandigowda Badarahe	2	14	55		V
	Mangalore	Baikampady Industrial Area	10	13	87		V
	Mysore	K.R.Circle, Visvesvaraya Bldg	10	20	77	38	V
	Raichur	KSPCB Office Premises, Raichur	23	28	284	77	III
	Shimaga	The VISL, Oxygen Plant, Shimoga	25	12	92	42	III
	Timukuru	KSPCB Office Premises	3	39	181		V
Kerala	Alappuzha	District Office, Alissery Road	2	5	69		V
		DC Mills, Pathirappally	2	5	76		V
	Kochi	Eloor I, FACT, Ambalamughal	4	40	99		V
		Eloor II	6	46	113		V
		Irumpanam	10	33	136		V
		Ernakulum South	7	25	136		V
		VYTTILA	9	44	188		V
		MG Road Bank Ernakulum	9	26	194		V
		KALAMASSERY / CSIR Complex	10	32	161		V
	Kollam	KSPCB, District Office, Kadappakada	3	7	54		V
		KMML Chavara	4	7	60		V
	Kottayam	Kottayam	4	14	57		V
		Vadavathoor	5	15	85		V
	Kozhikode	Kozhikode City	2	29	501	13	V
		Nallalam	2	23	131	12	V
	Malapuram	Kakkanchery, Sijmak oils	2	38	77		V
	Palakkad	SEPR Refractories India Ltd.	8	10	97		V
	Pathanamthitta	KSPCB, Makkamkunnu	2	19	39		V
	Thiruvanantha puram	PRS Hospital/COSMO	8	30	59		V
		SMV School	8	53	67		V
		VELI / HiTech Chackai	21	28	64		III
		PETTAH / Sasthamangalam	9	27	69		V
	Thissur	KSPCB, District Office, Poonkunnam	18	31	82		IV
	Wayanad	Sulthan Bathery	2	5	49		V
Lakshwadeep	Kavaratti	Power House Building (Second Floor)			60		V

Madhya Pradesh	Amlai	HJI	26	30	139	67	III
		OPM	24	27	151	70	III
	Bhopal	Hamidia Road, MP Hastshilp Vikas Nigam	20	46	276	142	IV
		CETP Govindpura	17	41	234	124	IV
		Nutan Subhash School, T.T. Nagar	8	15	183	117	V
		Kolar Thana, Kolar Road, Bhopal	18	36	294	117	IV
		AKVN Office, Industrial Area Mandideep, Raisen	26	48	295	142	III
		Barkatuallah University, Hoshgabad Road, Bhopal	12	40	225	97	IV
		Main Road, Hemu Colony, Bairagarh, Bhopal	16	47	218	90	IV
	Chhindwara	HIG -33, Front of Geetanali Park Housing Board Colony, Chadagaon	23	42	141	66	III
		Hindustan Unileaver, Narsinghpur Road,	7	32	119	58	V
	Dewas	EID Perry (I) Limited	20	24	85	96	IV
		Dewas Metal Section	21	27	131	96	III
		Vikas Nagar	20	25	80	96	IV
	Gwalior	Dindayal Nagar	16	26	235	90	IV
		Maharaj Bada	18	32	239	90	IV
	Indore	M.P. Laghu Udyog, Pologround	13	24	134	89	IV
		Kothari Market, M.G. Road	39	36	252	141	II
		Telephone Nagar, 26 A, Kanadia Road	16	32	273	115	IV
	Jabalpur	Vijay Nagar	2	29	231	104	V
		Udaipur Beverage Racchai	19	31	246	87	IV
	Katni	HIG-4 Housing Board Colony Jhinjhri, Katni	30	41	170	74	III
		Calderys Works Refactories India Private Limited, Guest House, Katni	27	37	152	80	III
	Nagda	Chem. D. Labour Club	33	27	85	44	II
		B C I Labour Club	20	33	80	38	IV
		Grasim Kalyan Kendra	23	30	116	55	III
	Prithampur	Vikas Bhavan, Sector-2	27	32	112	54	III
		RCC Over Head Tank No. 1, Sector-3	27	31	119	46	III
	Sagar	Pt.Deendayal Nagar	11	30	197	89	IV
		Katra Bazar, Sagar	6	24	141	72	V
	Satna	Sub-divisional Office E/M Light Machniery	6	13	210	98	V
		MPPCB,Dharwari GaliNo.5,House No.318	5	10	129	64	V
	Singrauli	Jayant Township	37	42	193	75	II
		N.T.P.C., Vidyanagar	32	70	198	74	II
		Waidhan	31	88	181	82	II
	Ujjain	District Office	19	20	116	56	IV
		Regional Office	17	18	116	46	IV
		Mahakal Temple	38	50	370	273	II
		Chamunda Mata Chouraha	18	19	136	58	IV
Maharashtra	Akola	LRT Commerce College, Civil Lines, Akola	14	14	94		IV
		MIDC Water Work, Phash-II, MIDC Akola	18	19	92		IV
		College Of Engineering & Tech, Akola	15	16	91		IV
	Ambernath	Ambernath Municipal Council Office	41	107	350		I
	Amravati	Apurva Oil Industries, A-23, MIDC	27	29	152		III
		Elect. Dept., Govt College Engineering	24	28	141		III
		Rajkamal Square, Vaneeta Samaj	27	29	140		III
	Aurangabad	S.B.E.S. College	27	51	91		III
		Collector Ofiice	16	37	92		IV
		C.A.D.A. Ofiice, Garkheda	24	48	94		III
	Badlapur	BIWA Office	38	101	256		II
	Bhiwandi	Prematai Hall, Near Dhamankar Naka	41	47	83		I
		Fire Brigade Office, I.G.M. Hospital	42	53	85		I
		Regional Office, M.P.C. Board, Kalyan	58	60	83		I
	Chandrapur	Grampanchat Ghughus	6	46	630		V
		M.I.D.C. Chandrapur	8	54	135		V
		Nagar Parishad	75	72	220		I
		Gadchandur Gram Panchayat, Rajura	6	46	274		V
		MIDC, Tadali	8	43	210		V
		Muncipal Council, Ballarshah	6	60	256		V
	Dombivali	Dombivali MIDC Phase-II	43	101	248		I
	Jalgaon	B. J. Market	21	44	138		III
		Girna water tank	19	42	127		IV
		MIDC Jalgaon	20	44	131		IV
	Jalna	Bachat Bhawan, Near S P Office	14	60	141		IV
		Krishidhan Seeds Ltd, MIDC Area	14	61	110		IV
	Kolhapur	University Campus, Shivaji University	19	36	88		IV
		Ruikar Trust, S.T. Stand	42	81	162		I
		Mahadwar Road, Near Mahalaxmi Temple	34	66	133		II
	Latur	MIDC Water Works	8	40	213		V
		Kshewraj Vidyalaya Shyam nagar	8	31	189		V

		Sidhheshwar Sahakari Bank Ganjgolai	8	35	200		V
	Mumbai	Bank of India, Kalbadevi Branch, Kalbadevi	4	52	256		V
		Parel TT, Ambedkar Road	7	61	458		V
		Worli	6	63	329	212	V
	Nagpur	Institution of Engineers	27	61	181		III
		Govt. Polytechnic College, Sadar	28	59	177		III
		MIDC Office Hingana Road	37	59	179		II
		MIDC Industrial Area, MIDC Office, Hingna	17	84	283		IV
		Nagpur Coop Building, Maskasath, Itwari	22	45	304		III
		NEERI Lab, Nehru Marg, Highway No. 7	18	56	232	111	IV
		MPCB Office Premises, Civil Lines	33	66	268		II
	Nashik	R.T.O. Colony Tank	24	29	171		III
		VIP Industrial Area, MIDC Satpura	22	30	193		III
		Nashik Municipal Council Building	22	38	204		III
		MPCB Sub R.O. Udyog Bhawan, Nashik	24	34	220		III
	Navi Mumbai	T.B.I.A, Rabale Airoli, TTC	33	76	337		II
		Dr. D.Y. Patil College, Nerul, TTC	27	66	228		III
		MPCB Lab, Mhape, TTC	26	71	140		III
		CIDCO Nodal Office Kharghar	27	69	200		III
		Water Pump House, Panvel, Taloja	27	71	137		III
		MIDC Collom Facility Building, Taloja	34	68	155		II
	Pimpri-Chinchwad	Bank of Baroda Builing, Near M.C Builiding	76	198	330		I
	Pune	Maratha Chamber of commerce, Bhosari	80	145	276		I
		State Electricity Board BLDG Nalstop	71	147	316		I
		Swargate Police Chawki	73	167	189		I
	Sangli	Udyog bhavan / SRO, MPCB Sangli	33	90	204		II
		Sangli- Miraj Primary school Building	44	149	185		I
		Krishna Valley School	18	123	212		IV
	Solapur	WIT Campus	19	42	87		IV
		Voronoko School / Chitale Clinic	19	41	88		IV
	Thane	Maternity Hospital, Dhobighat, Thane East	25	62	185		III
		Shahu Market,Naupada, Thane West	26	64	205		III
		Kolshet and Balkum, Thane West	22	61	282		III
	Ulhasnagar	Smt. C. H. M. College Campus	32	87	170		II
		Octroi Naka, Pawai-Chowk, Vithalwadi	37	142	296		II
Manipur	Imphal	Secretariat Building	100	53	187		I
Meghalaya	Byrnihat	EPIP, Ri-Bhoi district	34	17	280		II
	Dawki	Terrace building, Jaintia Hills District	4	15	30		V
	Khliehriat	O/o BDO, C & R.D. Block-Khliehriat	6	13	57		V
	Nongstoin	Office Premises of E.E, PHED	4	11	38		V
	Shillong	Boards Office Permises, Lumpyngngad	2	11	45	18	V
		State Tuberculosis Hospital	12	26	76		IV
		Forest Rest House, Polo Hills	7	16	52		V
		41/2 mile, Mylliem Range Office	4	15	62		V
	Tura	PHED, Araimille, West Garo Hills District	3	16	157		V
	Umiam /Umsning	Umiam Industrial Complex, Ri-Bhoi District	6	15	127		V
Mizoram	Aizawl	Khatla, M.G-Road, Mizoram SPCB	5	18	253		V
		Laipuitlang	2	12	61		V
		Bawngkawn	3	14	144		V
		Dawrpui Y.M.A, Building, Dawrpui	2	18	204		V
		Lengpui Airport, Model Veng, Lengpui	2	16	100		V
	Champhai	D.T.O Office Building, Kahrawt veng	2	5	42		V
		Lalzidinga building, Vengthlang	5	5	58		V
	Kolasib	H. Lalthuama Building, Project Veng	2	5	56		V
		Synod Bookroom, Building Diakkawn	2	5	48		V
	Lunglei	Thangkhuma Building, Salem Veng	2	5	12		V
		K.Lalliantluanga, Chanmari I, Lunglei	2	12	112		V
Nagaland	Dimapur	Bank Colony	2	23	248		V
		Dhobinala	2	20	273		V
	Kohima	Opposite NST Office	2	6	217		V
		Opposite War Cemetery	2	6	340		V
Odisha	Angul	Industrial Estate	20	35	154	85	IV
		NALCO Township	15	30	163	97	IV
	Balasore	Sahadevkhunta	4	14	144	95	V
		DIC office	3	14	141	89	V
		Rasalpur near Balgopalpur I/A	10	14	117	78	V
	Berhampur	Regional Office Orissa SPCB	20	25	107	65	IV
	Bhubneshwar	Capital Police Station	5	33	159	42	V
		IRC Village	8	26	172	65	V
		Office Premises Bhubaneswar	5	34	258	100	V

		Water works, Palasuni, Rasalgarh	5	50	169	41	V
		Patrapara, Khandagiri	2	23	130	46	V
		Chandrashekharpur	15	28	290	84	IV
	Bonaigarh	Govt. Hospital Bonai At/Po/PS-Bonai Dist-Sudargarh	18	23	230	182	IV
	Cuttack	Traffic Tower, Badambadi	6	38	166	73	V
		P.H.D Office Barabati	8	37	246	108	V
		R.O. Cuttack Office, Surya Vihar	9	42	213	100	V
	Jharsuguda	R.O. Building Cox colony	24	31	153	103	III
		TRL Colony, M/s. TRL Krosaki Refractories Ltd. PO: Bhepahar,	11	20	139	86	IV
	Kalinga Nagar	RO Office Building	3	21	191	60	V
		Maintenance Office of M/s NINL, Duburi	2	13	167	77	V
	Konark	Konark Police Station	4	17	197		V
	Paradeep	On roof of PPT Staff Quarter	35	21	317	161	II
		On roof of PPL Gueest	33	17	286	119	II
		On roof of STP building IFFCO	26	19	248	102	III
	Puri	Sadar police station	2	19	134		V
		Town Police Station	5	25	167		V
	Rajgangpur	DISIR, Rajgangpur	50	36	295	131	I
	Rayagada	Regional Office Orissa SPCB	19	31	161	118	IV
		LPS High School, Jaykaypur	14	27	149	96	IV
	Rourkela	Regional Office, ORPB	13	18	187	267	IV
		Kalunga Industrial Estate	20	32	265	93	IV
		IDL Police Out-post, Sonaparbat	15	20	110	101	IV
		Kuarmunda, Sundergarh	15	21	184	66	IV
	Sambalpur	Filter Plant, PHD Office, Modipara	39	43	287	220	II
	Talcher	Coal Field Area	13	34	183	86	IV
		T.T.P.S.Colony	15	34	206	97	IV
Puducherry	Karaikal	B.Ed College (PKCE), Nehru Nagar	12	19	71		IV
		Govt. Tourist Home, Kovilpathu	19	24	98		IV
		M/s Puducherry Power Corporation Limited, Polagam, T.R. Pattinam,	16	23	91		IV
	Puducherry	DSTC Office Upstairs, PHB 3rd Floor, AnnaNagar	5	15	78		V
		PIPDIC Ind. Estate Mettupalayam	5	16	71		V
		Chamber Of Commerce	6	14	65		V
Punjab	Aligarh (Jagraon)*	Forest Office, Vill:Aligarh, Teh:Jagraon	9	30	442		V
	Amritsar	R.O. Focal Point (earlier Nagina soap factory)	15	42	576		IV
		Vinod Chilling Center / Kochar Bhavan (earlier A-1,Platers)	16	41	818		IV
	Aspal Khurd(Tapa)*	Vill:Aspal Khurd, Teh:Tapa	8	25	205		V
	Bhatinda	Bathinda Milk Producers, Dabwali Road	7	32	160		V
	Binjon(Garshankar)*	CHC, Vill:Binjon, Teh: Garshankar	10	22	616		V
	Bishanpura(Payal)*	Longowalia Yarns (Unit-II), Vill-Bishanpura, Teh:Payal	15	30	780		IV
	Changal(Sangrur)*	Mastuana Sahib, Vill:Changal, Teh:Sangrur	7	23	218		V
	Chowkimann(Jagraon)*	Ludhiana College of Engineering,Vill:Chowkimann, Teh:Jagraon	10	30	682		V
	Dera BabaNanak	C-PYTE Building	8	15	566		V
	Dera Bassi	Punjab Chem and Crop Protection, Bhanakarpur Rd	10	20	428		V
		Winsome Yarns Ltd., Barwala Road	9	20	394		V
	Fatehpur (Samana)*	Baba Banda Singh Bahadur College, Vill:Fatehpur, Teh:Samana	7	13	132		V
	Gobindgarh	Modi Oil and General Mills, Mandi	9	47	142		V
		Raj Steel Rolling Mills, Mandi	9	48	238		V
		United Rolling Mills, Mandi Gobindgarh	9	45	229		V
	Guru Ki Dhab(Kotkapura)*	Vil:Guru Ki Dhab / Basti Himmatpura, Teh:Kotkapura	5	12	193		V
	Jaito Sarja(Batala)*	Royal Nursing College, Vill: Jaito Sarja, Teh: Batala	11	23	660		IV
	Jalandhar	Municipal Council Tubewell No. 27	15	25	794		IV
		Regional Office	14	25	660		IV
		Punjab Maltex , Kapurthala Road	14	25	371		IV
		Focal Point	17	29	808		IV
	Khanna	Markfed Vanaspati, Khanna	12	43	224		IV
		AS School, Khanna	11	43	299		IV
	Kharaori(Sirhind)*	Vill:Kharaori, Teh:Sirhind	6	19	435		V
	Kotladoom(Ajnala)*	Satyam College, Ramtirath Road, Vill: Kotladoom, Teh: Ajnala	9	24	434		V
	Lakho ke Behram(Ferozpur)*	Vill:Lakho ke Behram, Teh:Ferozpur	7	26	144		V
	Ludhiana	Bharat Nagar Chowk / RO Gill Road	17	56	626		IV
		Nahar Spining Mlls, Dholewal Chawk	16	58	494		IV
		Ludhiana Coop. Milk Producer, Ferozpur Rd	14	42	798		IV
		PPCB Office Building, Vishavkarma Chowk	19	53	446		IV
	Mrar Kalan(Muktsar)*	Vill: Mrar Kalan, Teh:Muktsar	7	23	201		V
	Mukandpur(Nawashahar)*	Govt. Senior Sec. School, Vill:Mukandpur, Teh:Nawashahar	10	21	217		V
	Mureedke(Batala)*	Johal Farm, Vill: Mureedke, Teh: Batala	11	21	402		IV
	Naudhrani(Malerkotla)*	Vill:Naudhrani, Teh:Malerkotla	6	23	239		V

	Naya Nangal	Punjab Alkalis & Chemicals Ltd	8	19	369		V
		M/s NFL Guest House,Naya Nangal	9	18	215		V
	Patiala	Ceylon Industries, Factory Area, Patiala	7	14	158		V
		Fire Brigade Station, Bahera Road, Patiala	7	15	169		V
	Peer Mohammad (Jalalabad)*	Vill:Peer Mohammad, Teh:Jalalabad	7	28	198		V
	Poohli (Bhatinda)*	Vill: Poohli, Teh:Bhatinda	8	20	600		V
	Qila Bharian (Sangrur)*	Gurdwara Gangsar Sahib, Vill:Qila Bharian, Teh:Sangrur	7	22	209		V
	Rakhra (Patiala)*	Shree Ganesh Group of Institute, Vill:Rakhra, The:Patiala	8	16	358		V
	Rohila (Samrala)*	Gopimal Kaur Sain Industries Pvt. Ltd, Vil:Rohila, Teh:Samrala	8	29	874		V
	Tirathpur (Amritsar I)*	United ITI, Vill: Tirathpur, Teh:Amritsar I (earlier Sriguru Harkishan Public School,Rasulpur Kalan)	8	14	205		V
Rajasthan	Alwar	Rajasthan State Pollution Control Board	12	76	246		IV
		Gaurav Solvex Ltd. MIA	16	44	353		IV
		RIICO Pump House, MIA	17	47	309		IV
	Bharatpur	Khadi Gramoday Samiti	10	36	387		V
		RIICO office Building	10	30	501		V
		RO, Building	8	26	347		V
	Bhiwadi	R.O.Building	41	173	447		I
		UIT Guest House	34	176	412		II
		Uttam Strips Ltd	39	196	438		II
	Chittorgarh	Regional Office building, RSPCB, Near FCI Godown, Chnaderiya	9	34	323		V
		Veterinary Hospital, Meeranagar	9	33	289		V
		PHED Pump House, Segawa	8	31	224		V
	Jaipur	Ajmeri Gate	17	65	478		IV
		RJPB Office,Jhalana Doongari	11	39	295		IV
		District Education Officer, Chandpole	10	46	359		V
		RIICO Office, M.I.A.	17	43	367		IV
		RSPCB, Vidyadhar Nagar	19	52	531		IV
		VKIA	22	60	592		III
		22,Godam, RIICO Office	36	47	328		II
		Mansarovar Nagar Niigam	32	41	440		II
		RIICO Office Sitapura Industrial Area	19	49	472		IV
	Jodhpur	DIC Office, Industrial Estate	12	56	560		IV
		Sojati Gate	14	52	378		IV
		Basni Industrial Area, RIICO Office	12	52	628		IV
		Maha Mandir Police Thane	10	51	483		V
		Office of Housing Board, Chopasani Road	11	50	799		IV
		Shastri Nagar Police Thana	10	54	588		V
		Kudi Mahila Thana	10	46	612		V
		Sangariya Police Choki	11	54	854		IV
		SoorsagarThana	10	49	479		V
	Kota	Regional Office, RJPB, Anantpura	24	37	454		III
		Municipal Corporation Building	12	42	335		IV
		Samcore Glass Ltd.	14	34	378		IV
		FireStation Nagar Nigam Shrinathpuram	10	39	393		V
		RajasthanTechnical University,Rawatbhata	9	38	573		V
		Sewage Treatment Plant, Balita, Kota	9	38	310		V
	Udaipur	Ambamata	18	45	409		IV
		Town Hall	22	49	289		III
		Regional Office,MIA	26	46	398		III
Sikkim	Chungthang	Chungthang	9	6	53		V
	Gangtok	White Hall Complex, Tasi view point	11	10	89		IV
		Metro Point Hospital Complex, Forest Secretariate Deorali	11	10	89		IV
	Mangan	Mangan Police Station	11	10	59		IV
	Namchi	Namchi	8	6	34		V
	Pelling	The Pelling Girls Hostel	15	12	80		IV
	Rangpo	Rangpo Fire Station	18	14	99		IV
	Ravangla	Ravangla Range Office	9	5	44		V
	Singtam	Police Station Building	59	22	99		I
Tamilnadu	Chennai	Govt. High School, Manali	17	22	99	58	IV
		Kathivakkam	16	20	76	46	IV
		Thiruvottiyur	16	19	91	49	IV
		Madras Medical College	35	42	158		II
		NEERI, CSIR CampusTaramani	24	80	90	68	III
		Thiruvottiyur Municipal Office	58	65	162		I
		Adiyar	12	19	177		IV
		Kilpauk	13	23	197	59	IV
		Thiyagaraya Nagar	14	49	196	58	IV
		Nunbakgum	19	28	342	55	IV
		Anna Nagar	12	35	292	59	IV

	Coimbatore	Poniarajapuram, On the top of DEL	10	33	204	136	V
		G.D.Matric Hr.Sec.School	11	63	141	102	IV
		SIDCO Office, Coimbatore/ Kurichi	9	38	121	94	V
	Cuddalore	Eachangadu Village	28	20	67	39	III
		SIPCOT (Project Office)	40	18	58	36	II
		DEE Office, Cuddalore	17	25	68	43	IV
	Madurai	Highway (Project -I) Building	18	55	141	92	IV
		Fenner (I) Ltd. Kochadai	22	32	139	131	III
		Kunnathur Chatram Avvai Girls HS School	22	37	190	85	III
	Mettur	Raman Nagar	11	32	97	56	IV
		SIDCO	11	36	124	58	IV
	Salem	Sowdeswari College Building	11	43	127	54	IV
	Trichy	Gandhi Market	25	30	215	117	III
		Main Guard Gate	27	30	205	134	III
		Bishop Heber College	22	26	208	74	III
		Golden Rock	19	29	211	82	IV
		Central Bus Stand	24	33	253	112	III
	Tuticorin	Fisheries College, Tuticorin Sipcot	18	17	170	85	IV
		Raja Agencies	20	16	178	110	IV
		AVM Jewellery Building	18	24	148	61	IV
Telangana	Adilabad	Building of SCCL Manadamarri Club Mandamarri, Mancherial	9	32	90	50	V
	Hyderabad	Balanagar	7	90	195	87	V
		Tarnaka, NEERI Lab. IICT Campus	13	27	162	134	IV
		Nacharam, Industrial Estate	15	24	172		IV
		ABIDS Circle General Post Office	15	34	178		IV
		Uppal, Modern Foods & Industries IDA	6	79	187	81	V
		Jublee Hills	6	57	170	113	V
		Paradise	6	77	175	70	V
		Charminar	7	93	177	79	V
		Zoo Park	12	107	220	126	IV
		Jeedimetla Industrial Estate, Rangareddy Distt.	8	103	200	137	V
	Karimnagar	On the terrace of the DIC building, Karimnagar	11	55	139	79	IV
	Khammam	Station Name: CER Club Khamam	14	89	156	44	IV
		Jalasoudha building	12	80	116		IV
	Kothur	Mehaboobnagar	13	81	153		IV
	Nalgonda	AP PCB Nalgonda	11	30	100	50	IV
		M/s. Srini Pharmaceuticals pvt. Ltd.Choutuppal (V & M)	11	36	98	62	IV
	Nizamabad	subashnagar,nizamabad dist	9	37	74	65	V
	Patencheru	Police Station, Medak, Ramachadrapuram	11	35	114	61	IV
	Ramagundam	Godavarikhani, Ramagundam, Karimnagar	39	57	177	82	II
	Sangareddy	Pashamylaram/Municipal Office	78	106	267	250	I
		Regional office Building of SANGAREDDY	7	32	100	52	V
		M/s. Mylan Industries, Gaddapothara	11	31	106	54	IV
	Warangal	KUDA Office, Hanumakonda	43	81	170		I
		Mee-Seva Building ,Municipal Complex	11	86	142	71	IV
Tripura	Agartala	SPCB, Pavivesh Bhawan, Pandit Nehru Complex, Gorkhabasti, Kunjaban	23	26	57	33	III
		Bordowali Bipani Bitan, Agartala MC, Bordowali, Near Nagerjala	37	31	159	72	II
Uttar Pradesh	Agra	Regional Office, Bodla	7	31	450		V
		Nunhai	9	34	574		V
		Taj Mahal	26	58	605	403	III
		DIC Nunhai	16	65	675	398	IV
		Etmad-uddaulah	13	64	644	292	IV
		Rambagh	21	64	424	279	III
	Allahabad	Square crossing circle of Laxmi Talkies	15	63	485		IV
		Bharat Yantra Nigam Ltd	15	51	437		IV
		Alopibagh/Sewage Pumping Stations	12	96	448		IV
		Jhonstonganj/co-operative Bank	12	111	464		IV
		Rambagh/Parag Dairy	9	79	364		V
	Anpara	Anpara Colony, Sonabhadra	23	35	320		III
		Renusagar Colony, Sonabhadra	24	34	313		III
	Bareily	IVRI Izatnaga	45	38	315		I
		Indian oetrol pump, Civil Line	44	40	679		I
	Firozabad	Center for Development of Glass Industry	12	44	371		IV
		Tilak Nagar	12	40	324		IV
		Raza ka Tal	11	37	330		IV
	Gajraula	Raunaq Auto Ltd, J.P. Nagar	37	51	356		II
		Indira Chowk, J.P. Nagar	43	61	487		I
	Ghaziabad	Atlas Cycles Industries, Sahibabad Ind. area	51	76	602	266	I
		Bulandshaar Road Industrial Area	46	73	625	296	I
	Gorakpur	M. M.M. Engineering College, Gorakhpur	25	43	321		III

		India Glycol Ltd. Gida, Gorakhpur	58	75	442		I
		Jalkal, Muncipal Corporation, Golghar	52	76	425		I
	Jhansi	Manik Chawk / Jal chauraha	8	28	140		V
		Veeranga Nagar	16	27	169		IV
	Kanpur	Forest & Training Centre, Kidwai Nagar	9	65	286		V
		Chamber Of Commerce Darshanpurwa / Deputy ka Parao	9	65	329		V
		Associated Chem Pvt Ltd, Fazalganj, Panki, Site- 5	9	64	285		V
		Head Post Office, Govind Nagar / Dabauli / Shastri NGR	9	61	269		V
		Jajmau / Awas Vikas	9	64	273		V
		I.I.T. Campus, Kanpur	2	26	316		V
		Indian Institute of Technology	2	23	337	277	V
		Dada Nagar, Kanpur	106	133	776		I
		Ramadevi, Kanpur	11	80	639		IV
	Khurja	Central Glass & Ceramic Research Institute	25	24	413		III
		Ahirpara	22	65	255		III
	Lucknow	Mahanagar	15	40	357		IV
		Chandganj Garden, Aliganj	12	40	435		IV
		Kapoor Hotel, Hazratganj	13	59	685		IV
		Talkatora	12	67	547		IV
		Aminabad / S.M.K Chowk	25	62	534		III
		Nagar Nigam	16	43	406		IV
		Ansal Technical Institute Campus, Ansal API	13	45	438		IV
		Vikas Khand	6	77	730	668	V
	Mathura	RO. UPPCB, 65 Baldevpuri, Maholi Road	13	28	179		IV
		CETP, Industrial Area, Mathura	16	33	196		IV
	Meerut	Begum Bridge	12	78	230		IV
		Thana Railway Road / Kesarganj	8	46	196		V
	Moradabad	Hindu College, Station Road	50	74	424		I
		Central Police Hospital, Civil Lines	39	51	369		II
	Noida	UP PPCB, E-12/1, Sector - 1	53	97	801	311	I
		Gee-Pee Electroplating and Eng. Work	53	103	1158		I
	Raebareli	Town Hall Colony, Ahmad Nagar, Gulab Road	10	17	158		V
		Khoya mandi Tiraha Lucknow Road Raebareli	16	21	173		IV
		Amawan Road Ind. Area Raebareli	12	18	171		IV
	Saharanpur	SRE-A, IIT Roorkee, Saharanpur Campus	25	35	352		III
		UPCL S.E. Office, Near Clock Tower	28	35	377		III
	Unnao	H. No. 5, Krishna Nagar	13	32	161		IV
		IIA Building, Industrial Area, Site 10	12	32	181		IV
	Varanasi	Regional Office, Jawahar Nagar	16	95	427		IV
		Sigra	32	103	464		II
		Saket Nagar	12	39	236		IV
		Banaras Hindu University	11	33	216		IV
		Chandpur	13	49	275		IV
Uttarakhand	Dehradun	Raipur Road, Near parag Diary	27	29	275		III
		Clock Tower, PWD Guest House	26	29	608		III
		Himalaya Drug Co. Near ISBT	27	30	433		III
	Haldwani	Govt. Women Hospital	32	25	138		II
	Haridwar	SIDCUL, Haridwar	22	26	190		III
	Kashipur	BSNL Office, Kashipur	24	30	229		III
	Rishikesh	Nagar Palika Parishad	23	28	207		III
	Rudrapur	SIDCUL Office	24	29	241		III
West Bengal	Alipurduar	Rabikanta High School	6	21	106		V
	Amtala	P Roy Industrial Training Institute, Amtala	7	48	226		V
	Asansol	Asansol Municipal Corporation	77	49	267	145	I
		Kangsabati Spinning Mill, Barjora	20	46	259		IV
		Burnpur Town Department, Burnpur	19	48	255		IV
	Baharampur	Md. Mozzammal Hossain's House	14	65	258		IV
	Balurghat	Balurghar College	7	23	109		V
	Bankura	Bankura Municipility	8	29	139		V
	Barasat	Barasat Municipility, 73 Rishi Bankim Chandra Road	21	73	253		III
	Bardhaman	Bardhaman Town, Rajbati	11	37	154		IV
	Barrackpore	Barrackpore Municiaplity	25	73	365	110	III
		Dum Dum Telephone Exchange	26	73	468		III
		Khardah Municipality	27	80	441		III
	Baruipur	Bauipur Police Station, Baruipur	10	51	257		V
	Bolpur	Bolpur Municipility	8	33	134		V
	Chinsura	Chinsura Municipility, Pipulpati Auto Stand	11	64	295		IV
	Coochbehar	ABM Seal College	6	22	112		V
		Uttarbanga Krishi Visvavidyalaya, Pundibari	6	20	105		V
	Dankuni	Krishnanagar Municipility, Dankuni	12	62	307		IV
	Darjeeling	Bose Institute Campus	5	19	75	44	V

Durgapur	DMC Water Works, Angadpur	21	46	261		III
	Kwality Hotel, Bhiringi More, Benachiti	21	49	273		III
	Bidhannagar, PCBL Club, Muchipara	24	51	256	136	III
	Dew India Limited, PCBL More, Durgapur	21	48	240		III
Ghatal	Annapurna Hotel, Ghatal-Panskura Bus Stand	16	42	136		IV
Haldia	Debhog Milan Viyapith, Bhabanipur	16	43	133		IV
	Bhunia Raichak, Driver's Hut, Bhunia	21	50	150		III
	Supermarket Building, Durgachak	20	47	119	46	IV
	WBIIDC Ruchi Soya Ind. Durgachak	21	48	155		III
Howrah	Howrah Municipal Corporation	21	160	514	290	III
	Naskarpara Pump House, Ghuseri	20	94	441		IV
	CDS & Health Centre, Bator	15	119	437	267	IV
	Howrah Municipality School, Bandhaghat	23	134	462		III
Jalpaiguri	Raninagar Jalpaigur	5	19	102		V
Jhargram	Jhargram	14	39	117		IV
Kalimpong	Kalimpong Municipality	5	19	79		V
Kalyani	College of Medicine & JNM Hospital, Kalyani Industrial Area	16	63	229	97	IV
Kharagpur	AMD Building, TATA Bearing	20	47	197		IV
Kolkata	Salt Lake, Rooftop of CK Market	10	62	300		V
	KMC office Building, Moulali	19	91	428	292	IV
	Minto Park, Inside Park AJC Bose Road	13	72	352	192	IV
	Dunlop Bridge, National Sample Survey	20	93	409		IV
	Behala Chowrasta, Traffic Guard Building	17	78	385	261	IV
	Upanagari Sporting Club, Baishnabghata	2	24	309		V
	Cossipore Police Station, B.T. Road	69	69	389		I
	Dalhousie Square, Lal Bazzar Police Headqtr.	86	86	361		I
	Kasba	41	41	358	335	I
	RD Kasba	37	105	289		II
	Infectious Diseases & BG Hospital, Beliaghata	10	70	323		V
	CESC Building, Mandeville Gardens, Gariahat	15	71	342		IV
	Administrative Building, Hyde Road	18	86	419		IV
	KMC Drainage, Pumping Station, 9 Mominpur Road, Mominpur	10	65	306		V
	Paribesh Bhawan	12	70	319		IV
	Milan Tirtha Club, Picnic Garden	8	62	277		V
	Public Health Engineering Office Building, Rajarhar	7	52	234		V
	Tennis Club Biulding, 45-46 Canal West Road,	16	83	383	285	IV
	Elite India Rubber Products Pvt.Ltd., Topsia	19	84	398		IV
	Maniktala Fire Station Building, 17, Bagmari Lane, Ultadanga	15	80	393		IV
	Tollygunge	10	62	318		V
Krishnanagar	Krishnanagar Municipility, TN Thakur Road	20	71	408		IV
Malda	WBPCB Office, Paribesh Bhaban, Vill.Abhirampur	5	21	111		V
Medinipur	Vidyasagar University	15	41	116		IV
Purulia	Purulia Municipility	10	27	135		V
Raigunj	Raigunj College	6	20	108		V
Rampurhat	Rampurhat Municipility	7	28	136		V
Ranaghat	Ranaghat Municipility, 11 school lane	20	72	361		IV
Raniganj	Raniganj Municipality	20	45	257		IV
	Mangalpur, SKS School Mangalpur	19	47	254		IV
	Jamuria Municipality	20	47	256		IV
Rishra	Rishra Municipility	14	71	308		IV
Sankrail	Bharat Co-op Housing Society	13	61	311		IV
	Bagan Police Station, Bagan	10	50	265		V
	Dhulagar Gram Pachayat	12	56	257		IV
	P Mukherjee's House, Near SBI Amta	13	44	266		IV
Siliguri	Siliguri	8	25	124	71	V
Suri	Suri Municipility	8	29	136		V
Tamluk	HP Gas Service Station, Maniktala	19	47	165		IV
Tribeni	Tribeni Health Center	10	54	256		V
Uluberia	ESI hospital nursing building, 3rd floor, Near Sahib Mandir	11	52	244		IV

GOOD

SATISFACTORY

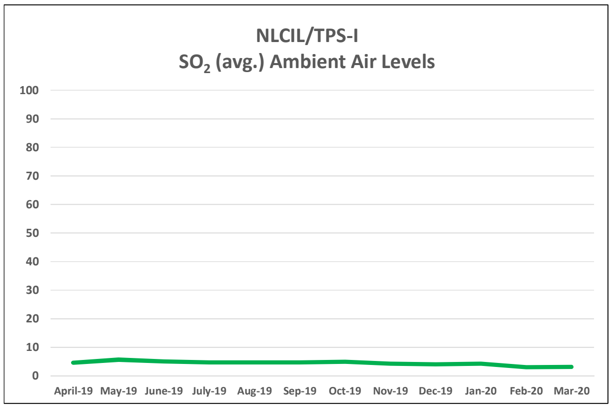
MODERATELY POLLUTED

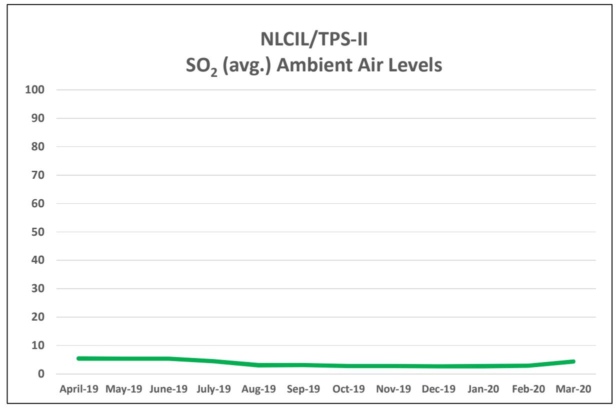
POOR

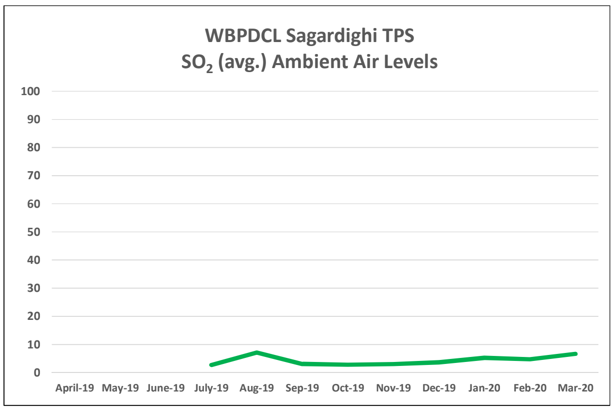
VERY POOR

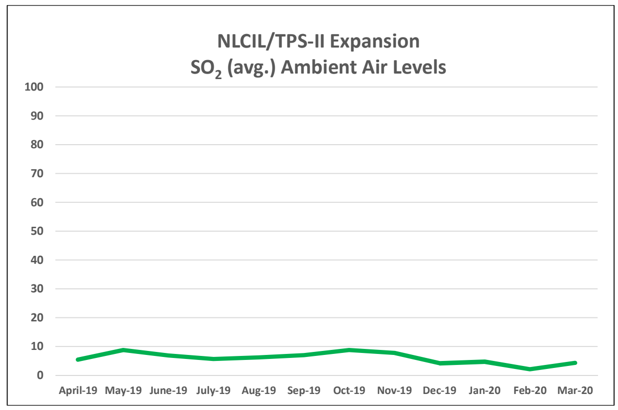
SEVERE

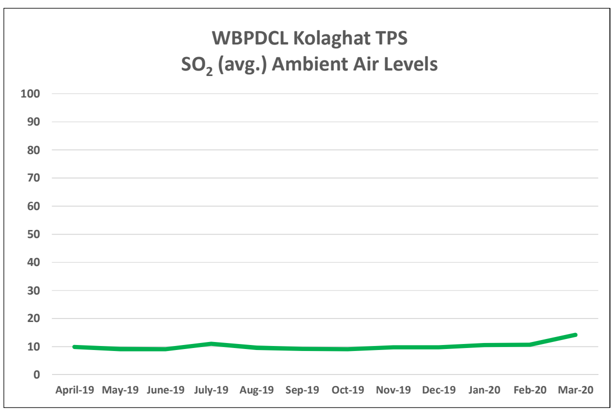
List of Power Plants according to SO_2 Levels in the Ambient Air and their Location

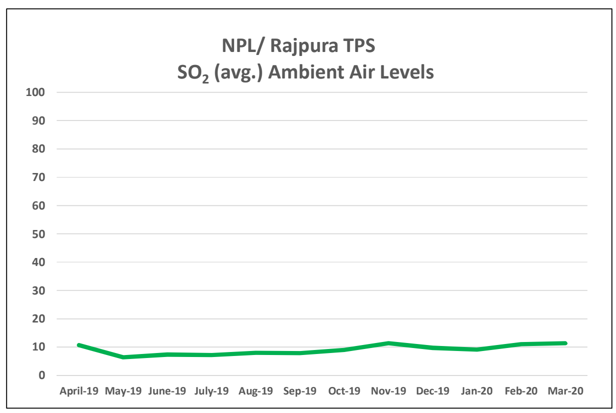


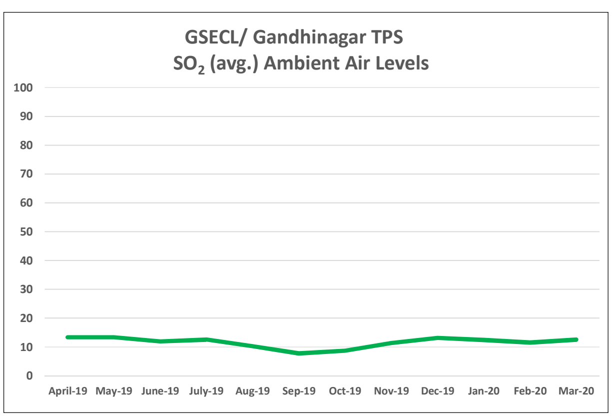


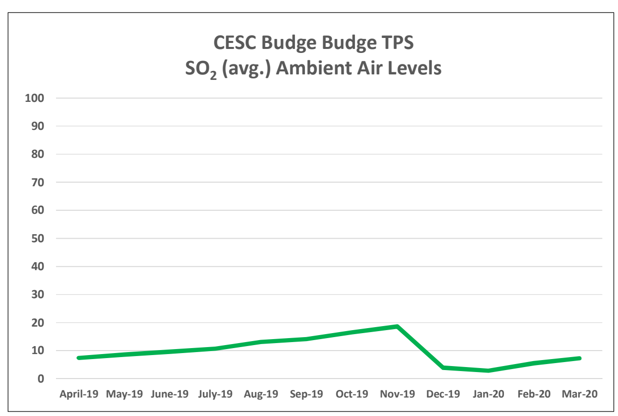


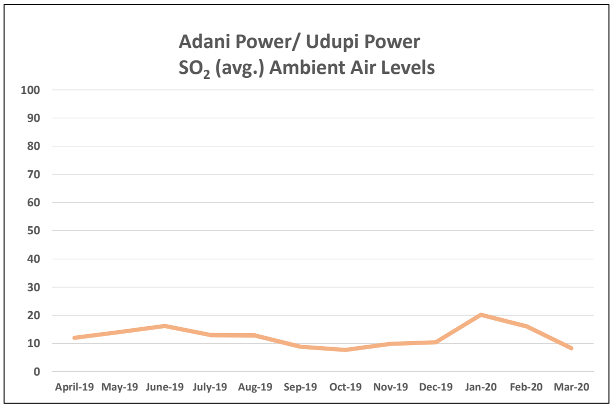


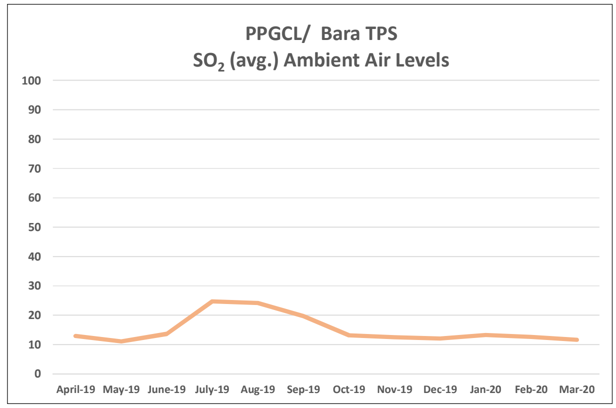


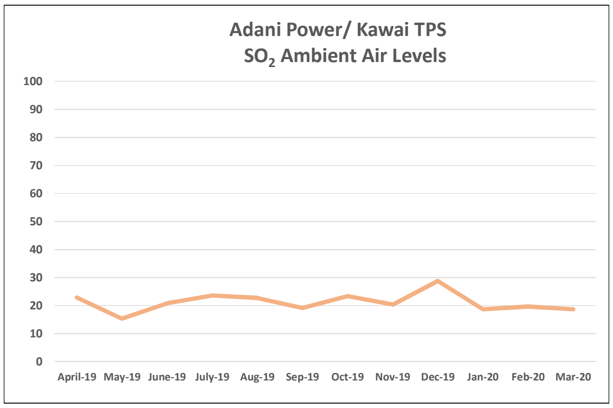


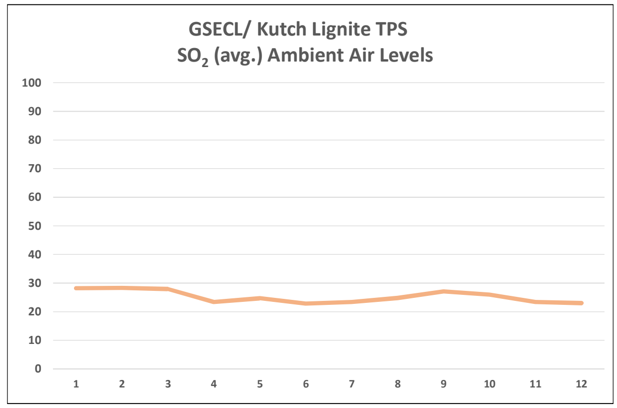





Adani Power/ Udupi Power
SO_2 (avg.) Ambient Air Levels
100
90
80
70
60
50
40
30
20
10
0
April-19 May-19 June-19 July-19 Aug-19 Sep-19 Oct-19 Nov-19 Dec-19 Jan-20 Feb-20 Mar-20


PPGCL/ Bara TPS
SO_2 (avg.) Ambient Air Levels
100
90
80
70
60
50
40
30
20
10
0
April-19 May-19 June-19 July-19 Aug-19 Sep-19 Oct-19 Nov-19 Dec-19 Jan-20 Feb-20 Mar-20


Adani Power/ Kawai TPS
SO_2 Ambient Air Levels
100
90
80
70
60
50
40
30
20
10
0
April-19 May-19 June-19 July-19 Aug-19 Sep-19 Oct-19 Nov-19 Dec-19 Jan-20 Feb-20 Mar-20


GSECL/ Kutch Lignite TPS
SO_2 (avg.) Ambient Air Levels
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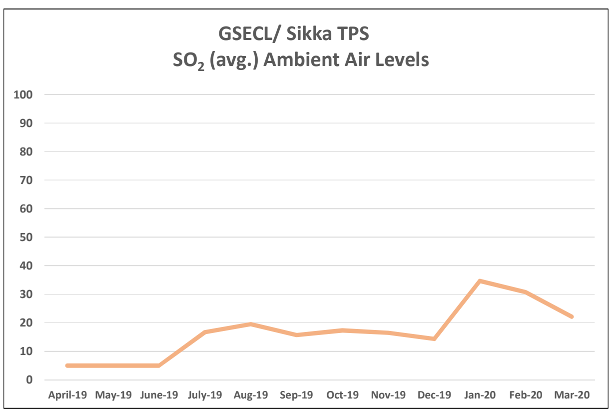
1 2 3 4 5 6 7 8 9 10 11 12


GSECL/ Sikka TPS
SO_2 (avg.) Ambient Air Levels
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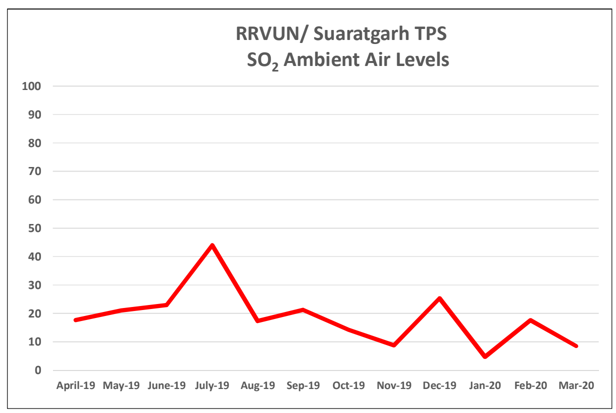
RRVUN/ Suaratgarh TPS
SO_2 Ambient Air Levels
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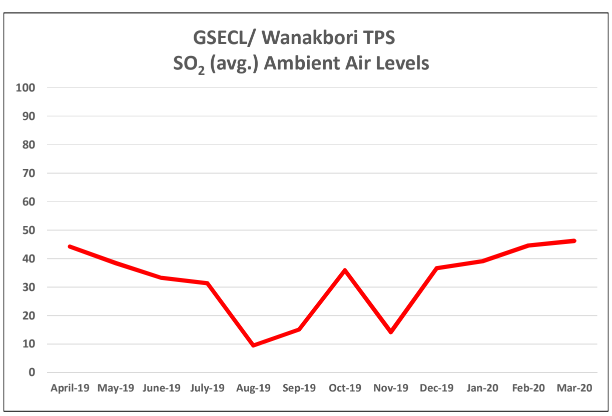
GSECL/ Wanakbori TPS
SO_2 (avg.) Ambient Air Levels
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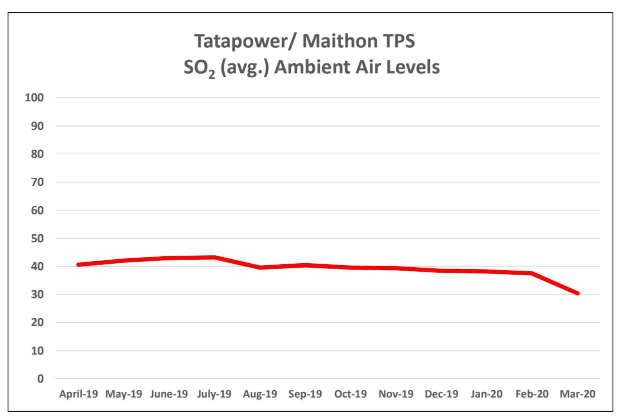
Tatapower/ Maithon TPS
SO_2 (avg.) Ambient Air Levels
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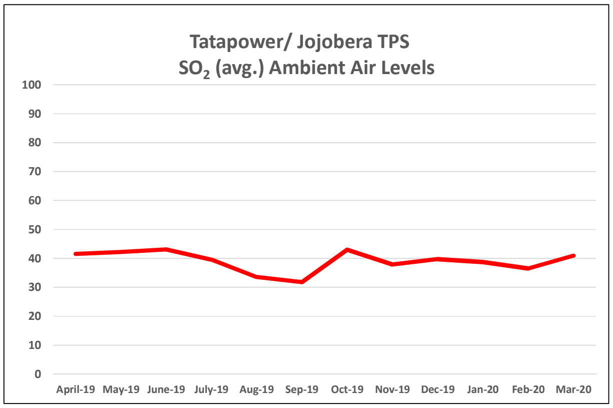
Tatapower/ Jojobera TPS
SO_2 (avg.) Ambient Air Levels
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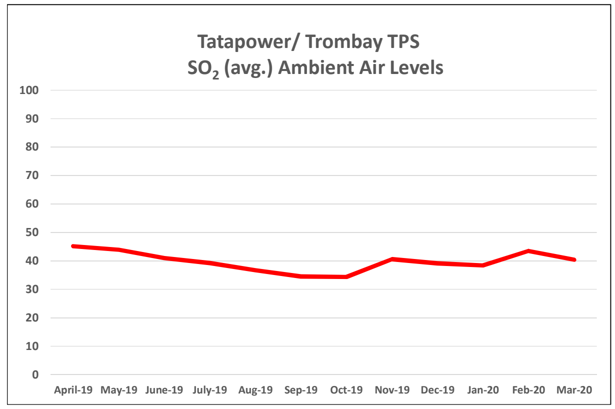
Tatapower/ Trombay TPS
SO_2 (avg.) Ambient Air Levels
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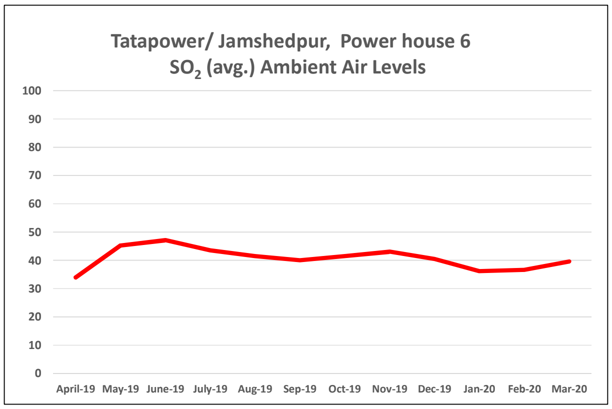
Tatapower/ Jamshedpur, Power house 6
SO_2 (avg.) Ambient Air Levels
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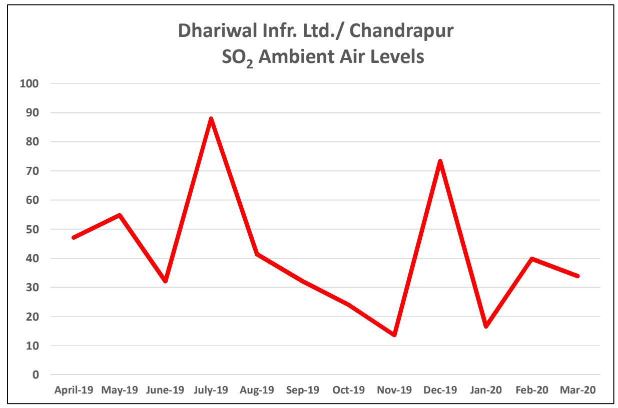
Dhariwal Infr. Ltd./ Chandrapur
SO_2 Ambient Air Levels
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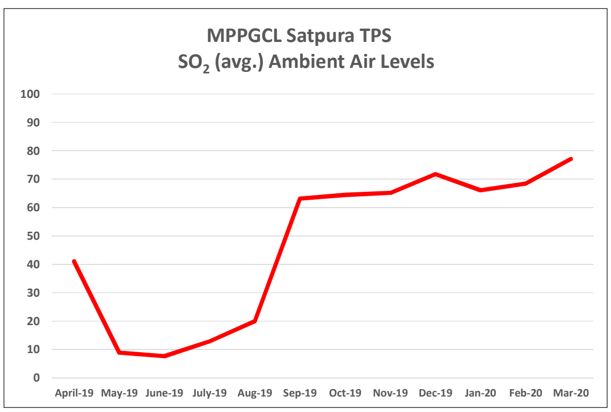
MPPGCL Satpura TPS
SO_2 (avg.) Ambient Air Levels
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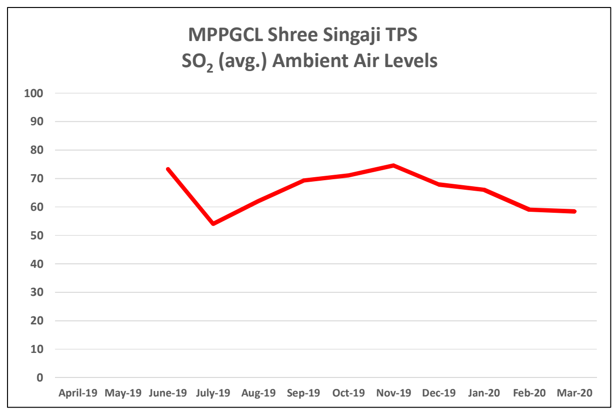
MPPGCL Shree Singaji TPS
SO_2 (avg.) Ambient Air Levels
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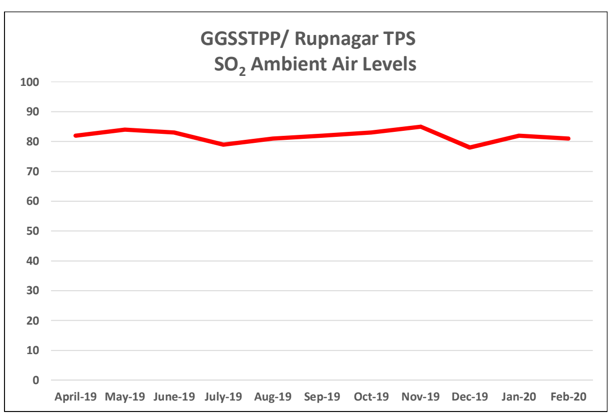
GGSSTPP/ Rupnagar TPS
SO_2 Ambient Air Levels
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Annexure-III

Air Quality Dispersion Modeling Study of Talwandi Sabo Power Ltd

(Final report)

Submitted to

Talwandi Sabo Power Ltd

Mukesh Sharma; PhD
Professor, Department of Civil Engineering
Indian Institute of Technology Kanpur, Kanpur- 208016
January 2020

Table of Content

1. Background

The important emissions from coal combustion include carbon dioxide (CO_2), nitrogen oxides (NOx), sulfur dioxide (SO_2), air-borne inorganic particles such as flyash, and other trace elements, especially mercury. Estimated emissions of major pollutants from coal-based power plants in the country are: 1.6 million tonnes of particulate matter, 1.5 million tonnes of NOx and 3.0 million tonnes of SO_2 every year and whopping over 160 million tonnes of flyash generation. These are large quantities. If we do not recognize this enormous environmental issue and not invest in technology, we pay through increased human morbidity and mortality. Science tells that sulfur and nitrogen oxides convert into fine particles of sulfates and nitrates posing greater health problem than the precursor gases sulfur and nitrogen oxides. To estimate the extent impact of SO_2 emission and its formation into sulfate particles, both short and long-distance modelling needs to be undertaken.

Talwandi Sabo Power Ltd has decided to conduct a modeling study related to SO_2 emission at their plant location Mansa, Punjab. In this context, Talwandi Sabo Power Ltd has desired that Indian Institute of Technology, Kanpur to undertake a study on air quality modeling through the state-of-the-art dispersion model AERMOD for dispersion and impact of SO_2 emission.

This report consists of the modeling exercise conducted from state-of-the-art dispersion model AERMOD.

2. The objectives of the Study

The study has the following objectives:

- Modeling of SO_2 and NO_x emission from Talwandi Power plant at a short distance as well as long-distance up to 250 km.
- Modeling of SO_4 and NO_3 formation precursor gaseous emission of SO_2 and NO_x from Talwandi Power plant at a short distance as well as long-distance up to 250 km.

3. The Scope of the Work

The study has the following scope of work:

1. Modeling Study on the dispersion of Pollutants, mainly Sulphur dioxide emission from the plant.

2. Estimating an increase in Sulphur dioxide and sulfate at GLC (ground level concentration) using both Short distance and long-distance dispersion model.

4. Data Availability

All the data related to plant emission is provided by Talwandi Sabo Power Ltd.

S.No	Description	Details
1	Geographical coordinates of all the stacks. (latitude and longitude)	29°55'18"N, 75°14'10"E
2	Stack Height from GL	275 M
3	Stack diameter at top	Chimney is constructed with RCC shell. RCC shell has the top diameter of 10.45M and each flue can have the diameter of 7.2M. Chimney drawings enclosed for reference.
4	Exit Gas velocity	25 m/s at full load (660 Mw), 17 to 19m/s at 350 Mw
5	Stack Temperature	125 to 130 Deg.C
6	Stack pressure	not available
7	Stack Monitoring Reports of each stack	CEMS stack monitoring report enclosed
8	The emission rate of pollutants (measured)	SO2- 0.975 Kg/Sec (not measured at plant and calculation sheet with last FY average Fuel characteristics have been enclosed)
9	Fuel Characteristics (sulphur and nitrogen content)	FY18-19 yearly average fuel charecteristics : i. Carbon-41.55% ii. Hydrogen- 2.57% iii. Nitrogen- 0.77% iv. Oxygen- 4.90% v. Sulphur- 0.41% vi. Ash- 33.30% Moisture- 16.49%
10	Fuel usage (per day or per year) including oil	FY18-19 yearly coal consumption- 68,73,215 MT FY18-19 yearly Oil consumption: LDO- 1810 KL, HSD-232 KL, HFO- 1841 MT
11	Observed Meteorological Data	TSPL weather data Enclosed
13	Capacity/power of ID and FD fans	1. ID fan (2x60% capacity at worst coal) :- 2523600m3/hr / power 5.4 MW 2. FD fan(2x60% capacity at worst coal) :- 993600 m3/hr / Power 2.1 MW
14	Type of firing in boiler	Pulverised coal CUF（circular Ultra Firing） wall tangential staged firing
15	Plant load factor	61.34 % (for FY 2018-19)
16	Last years energy generation and coal consumption	Energy generation :- 10639.91 Mu for 2018-19 Coal consumption :- 6873215 MT for 2018-19
17	Gas flow rate in the stack	23,77,880 Nm^3/hr on dry basis

The SO_2 emission rate has been taken as 2.77 kg/s which refers to full load generation (1980 MW) for modelling exercise for SO_4. For the purpose of estimation of SO_2 model concentration, to facilitate the comparison with actual measured data, it was taken as per the coal consumption in the FY 2018-19 at 1.70 kg/s. For NOx, the emission is taken as 0.55 kg/s as per the ratio of NO_x to SO_2 emission (20%).

5. Dispersion Modeling Methodology

The current state-of-the-science, comprehensive meteorological and regulatory air dispersion modeling systems including WRF-CHEM (Grell, et al., 2005) modeling has been used to assess the short- and long-range transport of pollutants (Figure 1).

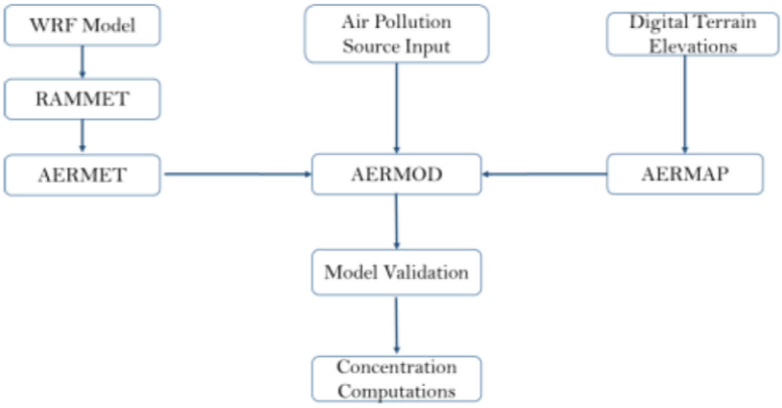


Figure 1: Methodology adopted for the Study

American Meteorological Society/ Environmental Protection Agency's Regulatory Model (AERMOD) having the ability to characterize the planetary boundary layer (PBL) through both surface and mixed layer scaling has been used. This model is called AMS/USEPA regulatory model or AERMOD which is a complete and powerful air dispersion modeling package which seamlessly incorporates the following popular US EPA air dispersion models into one integrated interface:

- AERMOD
- ISCST3
- ISC-PRIME

The AERMOD modeling system consists of one main program (AERMOD) and two pre-processors (AERMET and AERMAP). AERMOD uses terrain, boundary layer and source data to model pollutant transport and dispersion for calculating temporally averaged air pollution concentrations.

Onsite hourly meteorological data were generated by WRF (weather research and forecasting) model. The model domain area up to 250 km (domain area 400 x 400 km^2) towards prevailing downwind direction was considered. NCEP FNL (Final) Operational Global Analysis data with the temporal resolution was used as an input to WRF. The output of WRF model (i.e. meteorological data) was used as the input to AERMOD in pre-processor RAMMET and AERMET of the model. These meteorological parameters (wind speed, wind direction, rainfall, temperature, humidity, pressure, ceiling height, global horizontal radiation, and cloud cover) were obtained from WRF model. The terrain data at 90 m resolution of Shuttle Radar Topography Mission (SRTM) were used in AERMAP which is also the pre-processor of AERMOD. This provided a physical relationship between terrain features and the behaviour of air pollution plumes and generates location and height data for each receptor location.

5.1 WRF - Meteorological Modeling

The next-generation, non-hydrostatic, mesoscale Advanced Research Weather Research and Forecasting (WRF-ARW) model version 3.6 was used as the meteorological model for providing dynamic meteorological parameters as inputs to WRF-Chem models. The modeling domain for the meteorological modeling system was set up for the entire study area with a spatial grid resolution of 4.0 km at a regional level. The model was optimized for various parameters by achieving the best possible meteorological validation. Simulations were done for the winter and summer months. The initial and lateral boundary conditions for the WRF model was obtained from National Centers for Environmental Prediction (NCEP), USA in the form of FNL (Final Analysis) data, available at every 6-hour interval and at a spatial resolution of 0.1^0 x 0.1^0 containing geo-potential height, pressure, horizontal and vertical wind components, temperature, specific humidity and cloud cover at various vertical levels up to the top of the troposphere along with the soil temperature and soil moisture. The WRF output files were post-processed for visualization and application in the air quality models.

5.2 WRF-Chem Modeling

WRF-Chem has been used to investigate the impact of sulfate and nitrate with combinations of RADM2 (Second Generation Regional Acid Deposition Model) chemical mechanism and MADE/SORGAM (Modal Aerosol Dynamics Model for Europe/Secondary Organic Aerosol Model) aerosols including some aqueous reactions for secondary inorganic (SIA). Gas-phase chemistry, aerosol chemistry, wet scavenging and cloud chemistry option were turned on in the simulations. The emission inventory for the plant is prepared and make it compatible with the WRF-Chem.

6. Study Area Description

Talwandi Sabo Power Limited (TSPL) was incorporated as an SPV by Punjab State Electricity Board (PSEB) with the purpose of constructing a 1980 (3×660) MW thermal power plant at Village Banawala, Mansa-Talwandi Sabo Road, District Mansa, Punjab, India (Figure 2). Sterlite Energy Limited (a Vedanta group company) was selected as the developer of the project based on the Tariff Based Competitive Bidding Process (Case-2) on BOO basis for supply of 100% power to Punjab State Electricity Board (PSEB) for 25 years as per the guidelines of Government of India. Power Purchase Agreement and other related agreements were signed between TSPL and PSEB on September 1, 2008, and the ownership of Talwandi Sabo Power Limited was transferred to Sterlite Energy Limited (Now Vedanta Limited) on that date.

Figure 2: Plant Location

Talwandi Sabo Power Limited (TSPL), an ISO 9001:2015; ISO 14001:2015, ISO 45001:2018, ISO 39001:2018 and ISO 50001:2018 certified company & wholly owned subsidiary of Vedanta Limited implemented the largest 1980 (3×660) MW Greenfield Power Project in Punjab, India, with all consents and approvals in place.

TSPL is one of the first few Supercritical plants being constructed in the country. The Supercritical technologies are environment friendly and energy efficient technologies.

7. Meteorological Data

In evaluating the emission dispersion from the Talwandi Sabo power plant, the meteorological dataset was generated using the weather research and forecasting model for the period of January 01, 2018 – December 31, 2018. The frequency distribution and a frequency count data are obtained by processing the hourly surface file. The wind rose diagrams are shown in Figure 3.

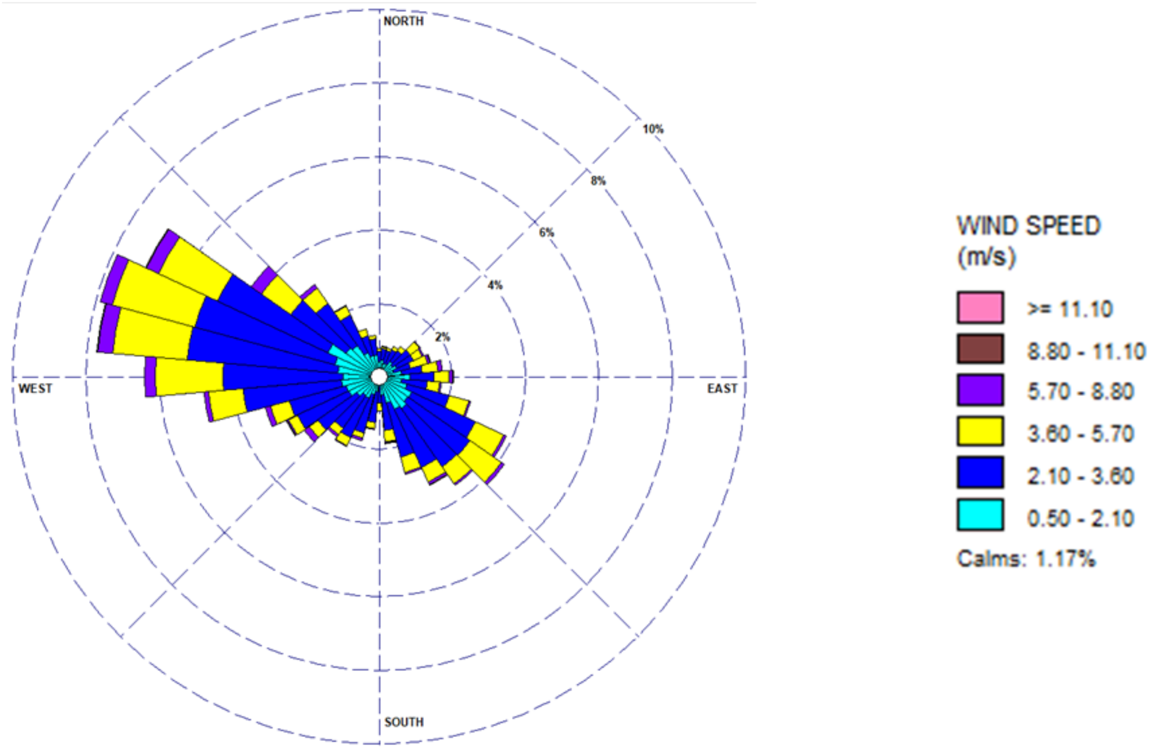
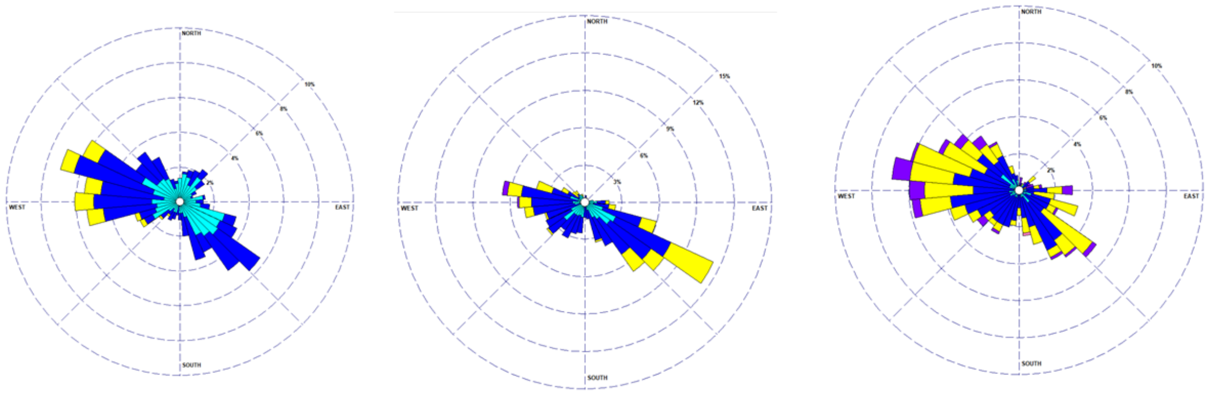


Figure 3 Wind Rose Plot for the year 2018



December January April

Figure 4 Wind rose plot the main month in different season

The AERMET program is a meteorological pre-processor that prepares hourly surface data and upper air data for use in the USEPA air quality dispersion model AERMOD.

8. Digital Terrain Elevation Model

The DEM is the most critical information required for complex terrain. The terrain affects the dispersion significantly. The advantages of DEM are:

- DEM is required to predict wind flow patterns and dispersion.
- Receptor elevations will be required for air quality analysis. The DEM is necessary for determining receptor elevations.
- AERMOD processes Digital Elevation Model (DEM) data and creates an elevation and height scale (the terrain height and location that has the greatest influence on dispersion) for each receptor in the domain.
- In complex terrain, AERMOD simulates a plume according to the concepts of the critical dividing streamline that defines which plumes flow over the hill and which flow around it. USEPA recommends the use of AERMOD while modeling in complex terrain.
- Special attention to DEM is given to obtain the results with better accuracy and precision.

The terrain is the vertical dimension of the land surface. Gridded terrain elevations for the proposed modeling domain were derived from 3 arc-second digital elevation models (DEMs) produced by the United States Geological Survey (USGS). Data are provided in files covering 1 degree by 1-degree blocks of latitude and longitude. The processed terrain elevation data is shown in Figure 5.

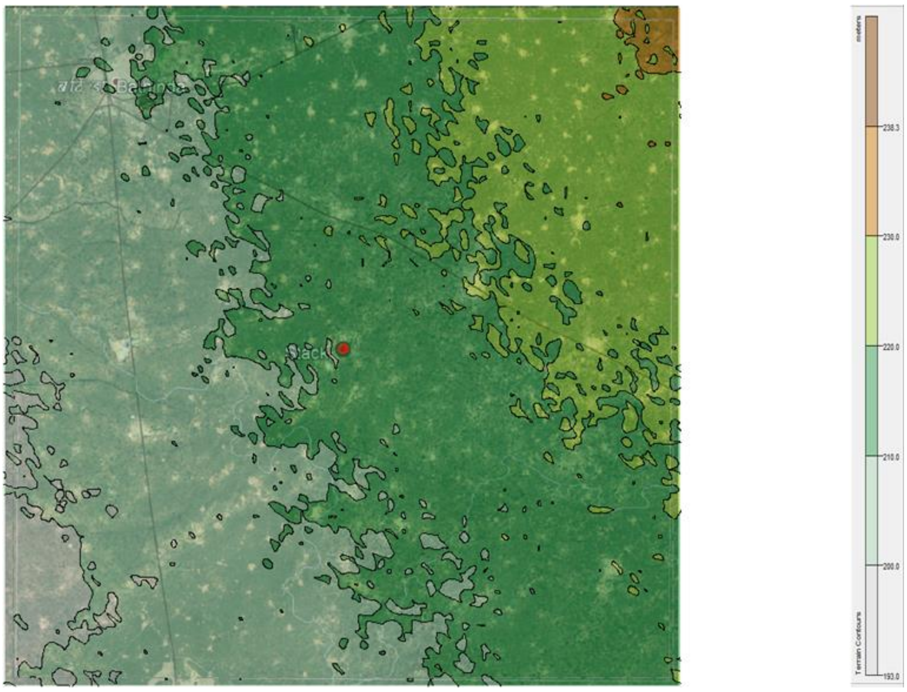


Figure 5 DEM of the study area

9. Receptor Elevation

Receptor elevations were obtained from National elevation dataset (NED) distributed by the USGS. The NED data was processed with AERMAP, a pre-processor program which was developed to process terrain data (base elevation and hill height scale data) in conjunction with a layout of receptors and sources to be used in AERMOD. For this study, the model was run with elevations and without elevation to understand the effect of hills.

10. Evaluation of Dispersion Modelling Results

The air dispersion modeling was done with complex terrain (using the elevation heights in the project area). By this approach, all the elevations of terrain are accounted, and the air dispersion will reflect more accurate results as compared to flat terrain.

The air quality modeling results for SO_2 from Talwandi Sabo Power Plant is presented in Table 1. The peak concentration varies from 25.47 to 45.9 µg/m3.

Table 1 SO_2 Air Quality Modeling results of Talwandi Sabo Power Plant

Month	Peak Concentration ($\mu g/m^3$)	Average Concentration ($\mu g/m^3$)
December	25.47	8.75
January	29.8	13.7
April	45.9	12.1

The peak and average concentration at different locations (distance) are presented in Table 2:

Table 2 SO_2 results at distances towards direction of Delhi of Talwandi Sabo Power Plant

Month	SO_2 ($\mu g/m^3$)	10km	20km	30km	40km	Beyond 40km	Date
December	Peak Concentration	14	8	6	4	<4	12-12-2018
	Average Concentration	4.5	2.5	1.7	1.5	<1	-
January	Peak Concentration	13	7	5	4	<4	31-01-2018
	Average Concentration	2.5	1.4	1	0.7	<0.7	-
April	Peak Concentration	7	3	1	0	0	22-04-2018
	Average Concentration	2.5	1.2	1	0	0	-

The wind rose & Iso-concentration graph of SO_2 and central line GLC and terrain contour is shown in Figure 6 to 32.

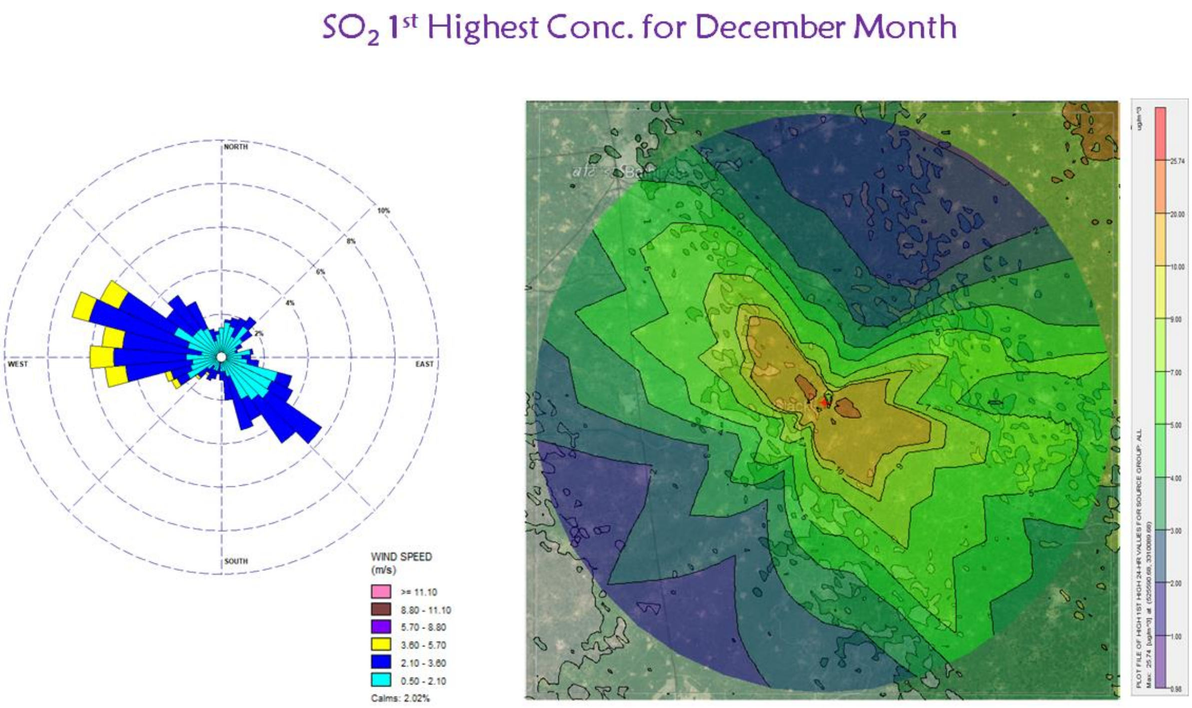


Figure 6 SO_2 1st Highest Conc. for December Month

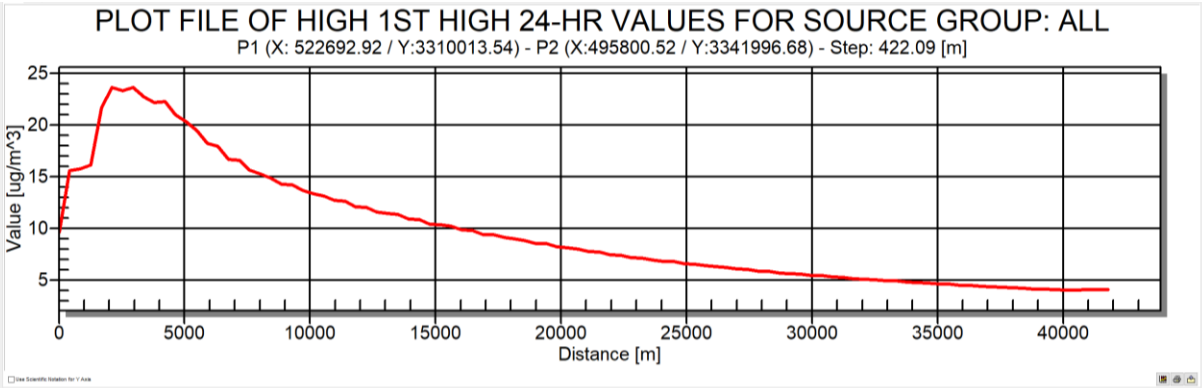


Figure 7 SO_2 1st Highest Conc. Cross Section towards Bhatinda

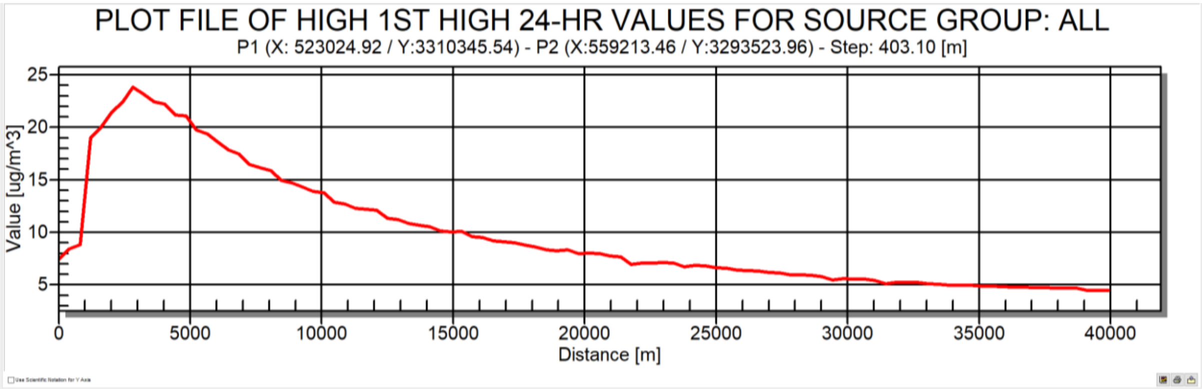


Figure 8 SO_2 1st Highest Conc. Cross Section towards Delhi

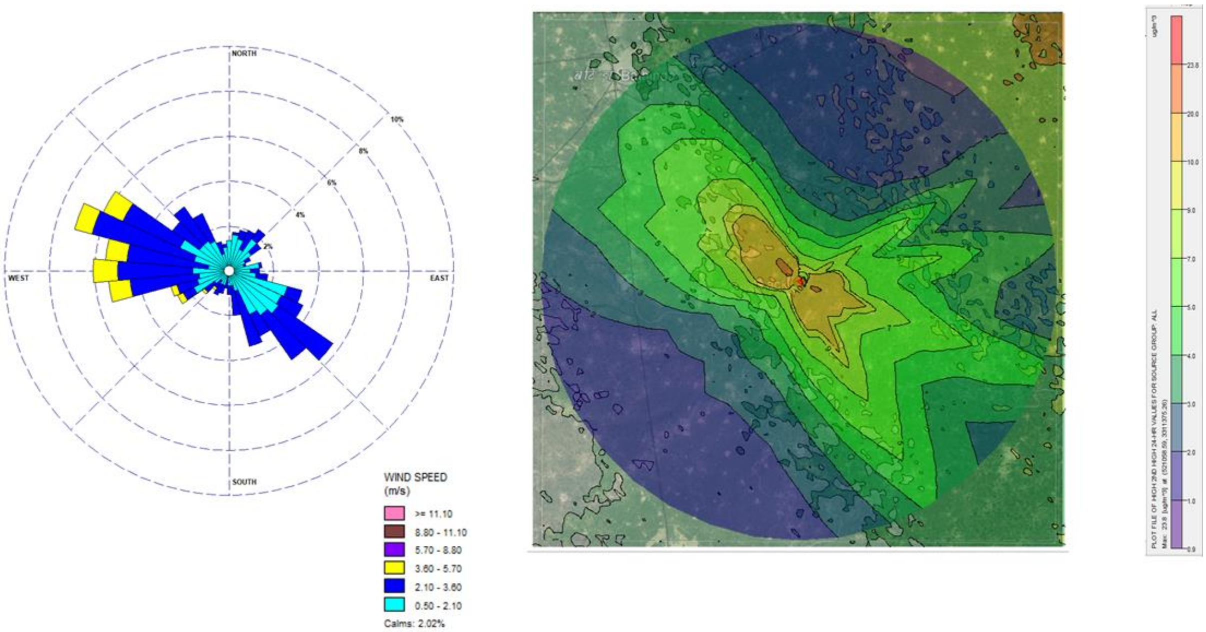


Figure 9 SO_2 2nd Highest Conc. for December Month

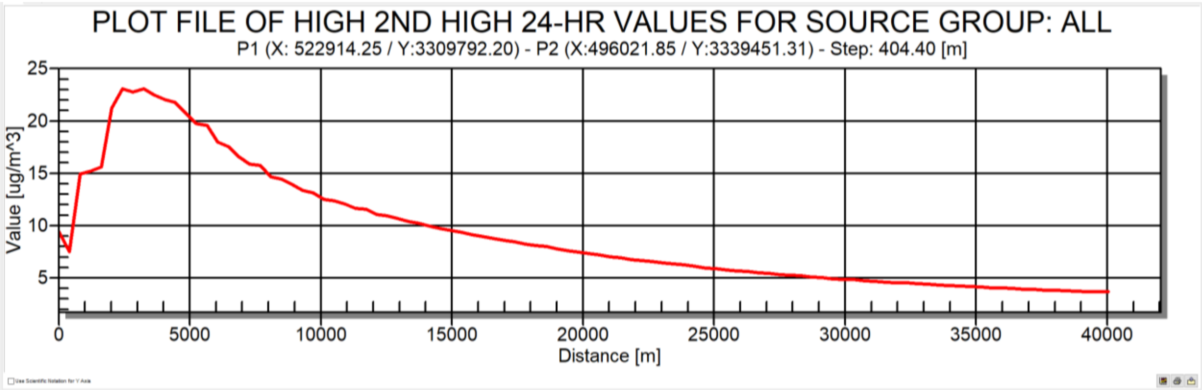


Figure 10 SO_2 2nd Highest Conc. Cross Section towards Bhatinda

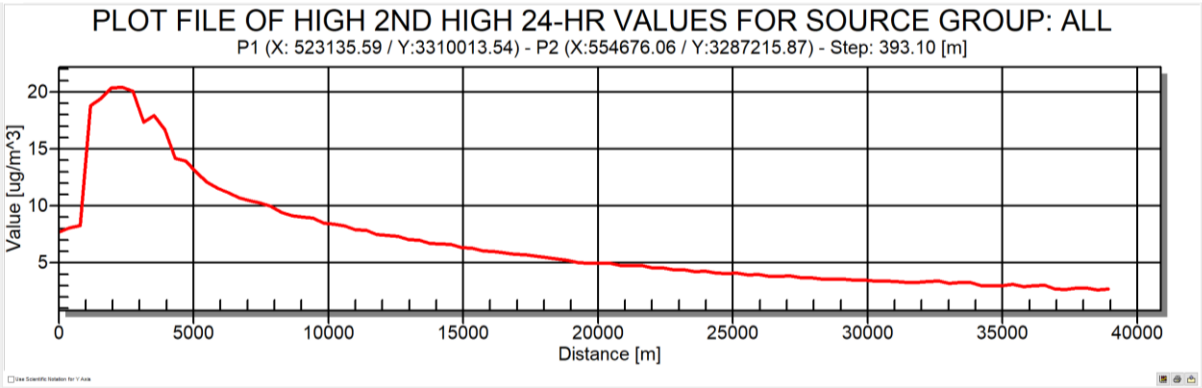


Figure 11 SO_2 2nd Highest Conc. Cross Section towards Delhi

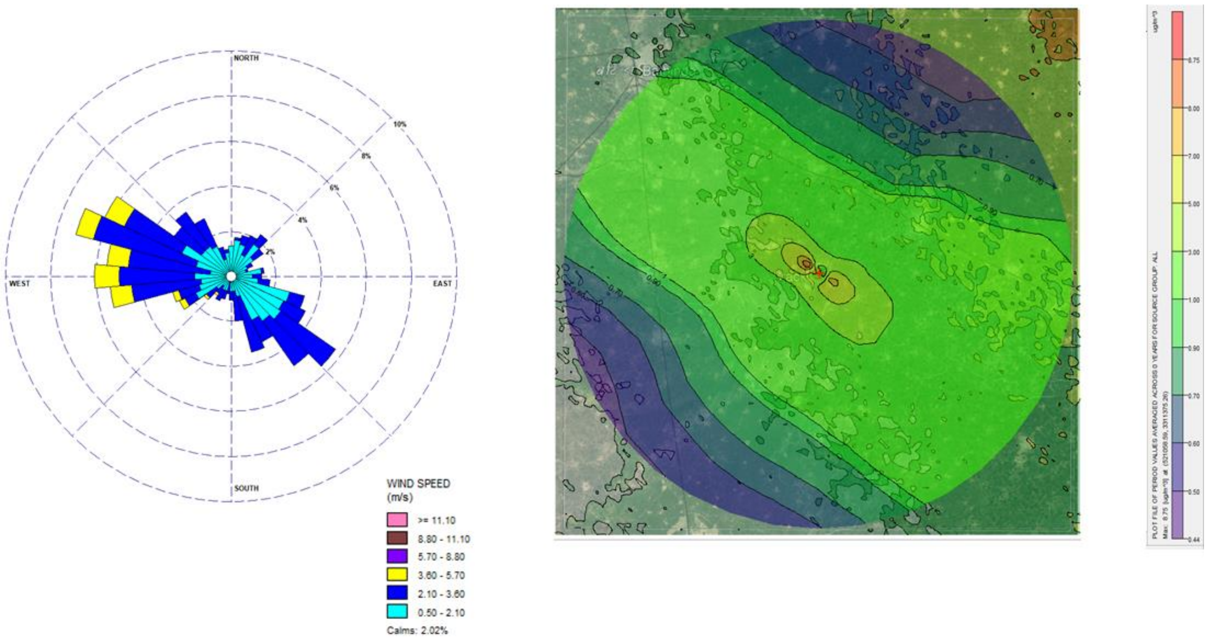


Figure 12 SO_2 Average Conc. for December Month

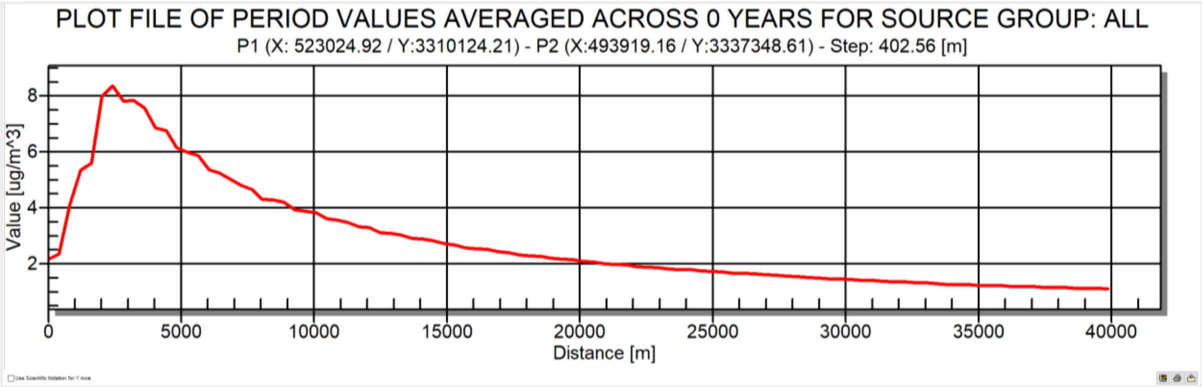


Figure 13 SO_2 Average Conc. Cross Section towards Bhatinda

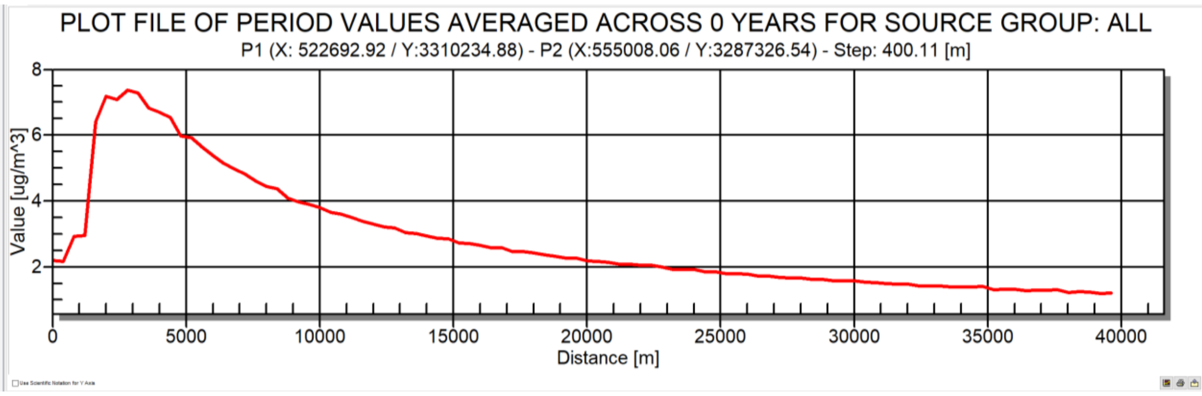


Figure 14 SO_2 Average Conc. Cross Section towards Delhi

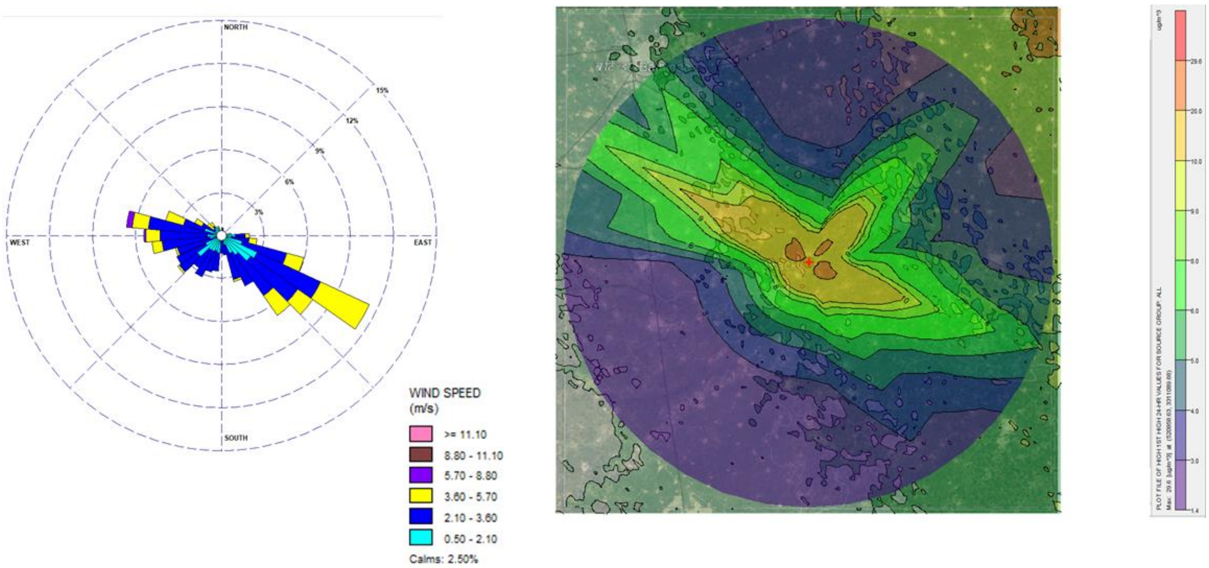


Figure 15 SO_2 1st Highest Conc. for January Month

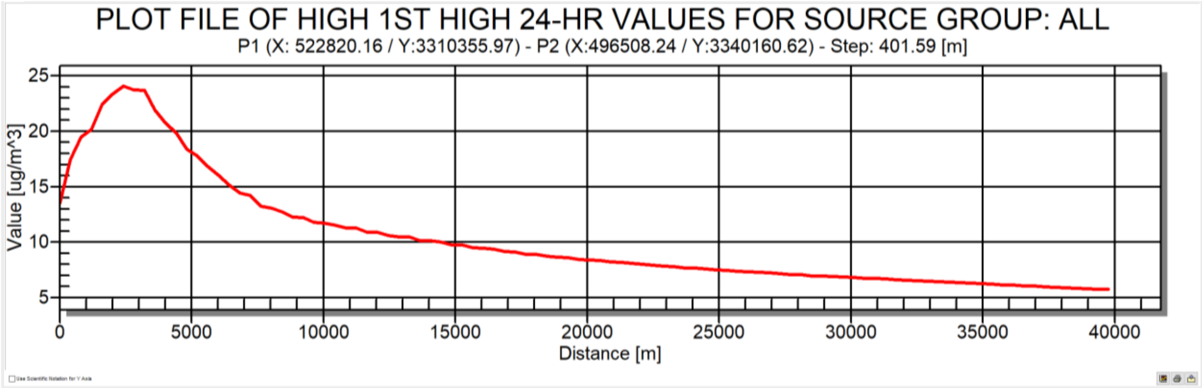


Figure 16 SO_2 1st Highest Conc. Cross Section towards Bhatinda

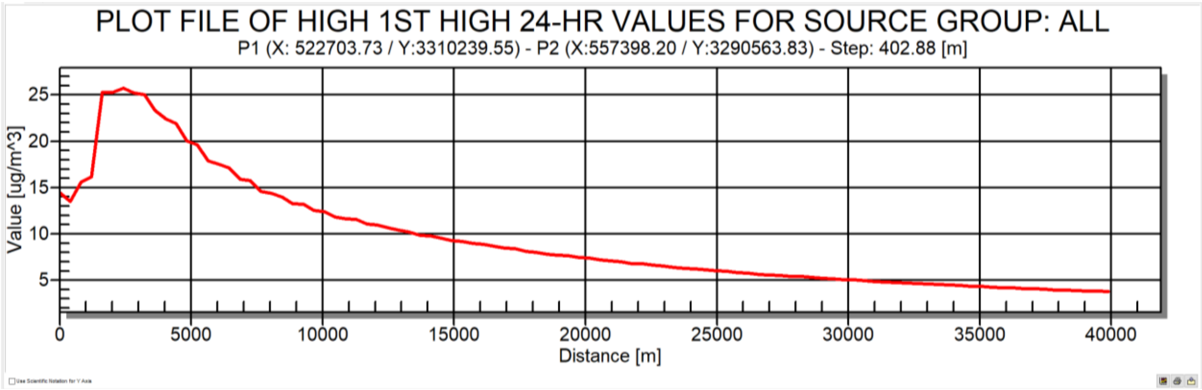


Figure 17 SO_2 1st Highest Conc. Cross Section towards Delhi

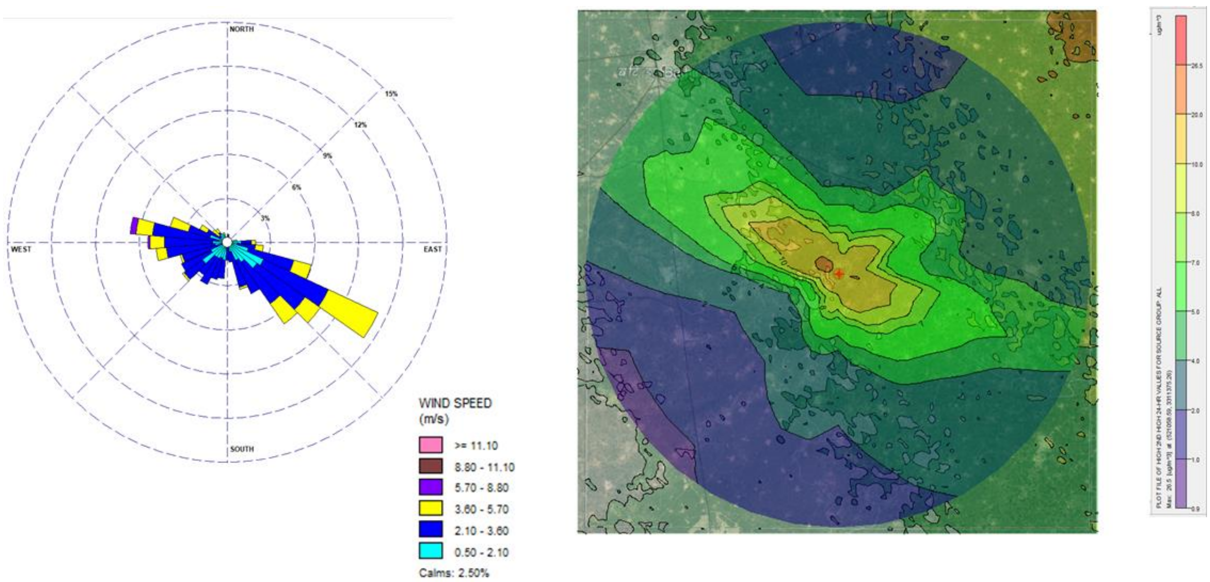


Figure 18 SO_2 2nd Highest Conc. for January Month

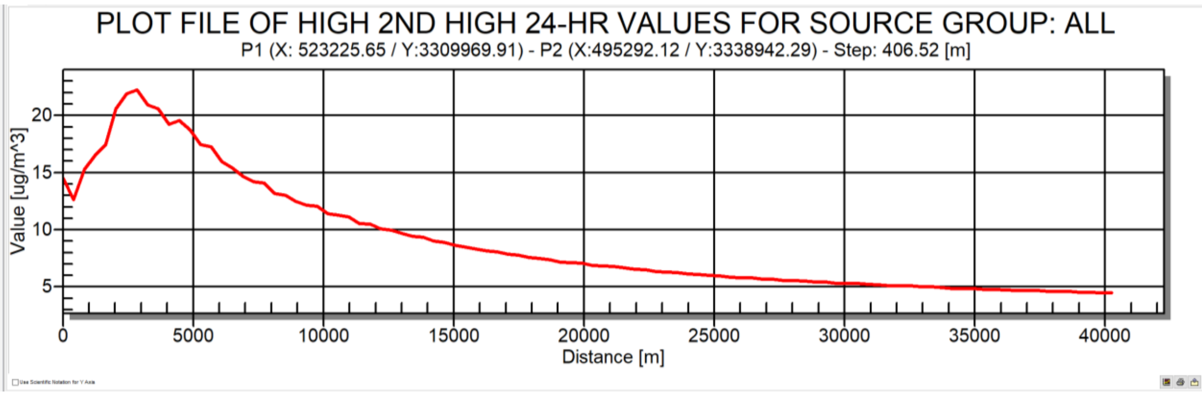


Figure 19 SO_2 2nd Highest Conc. Cross Section towards Bhatinda

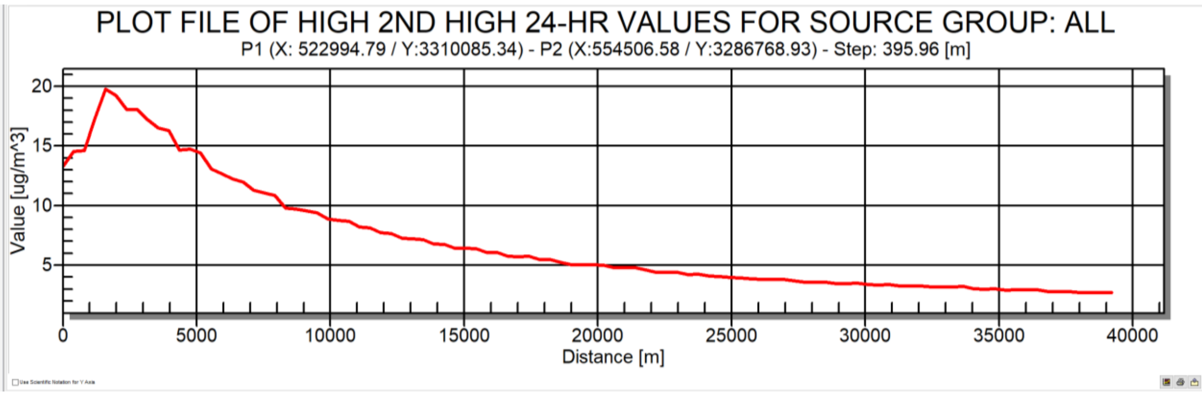


Figure 20 SO_2 2nd Highest Conc. Cross Section towards Delhi

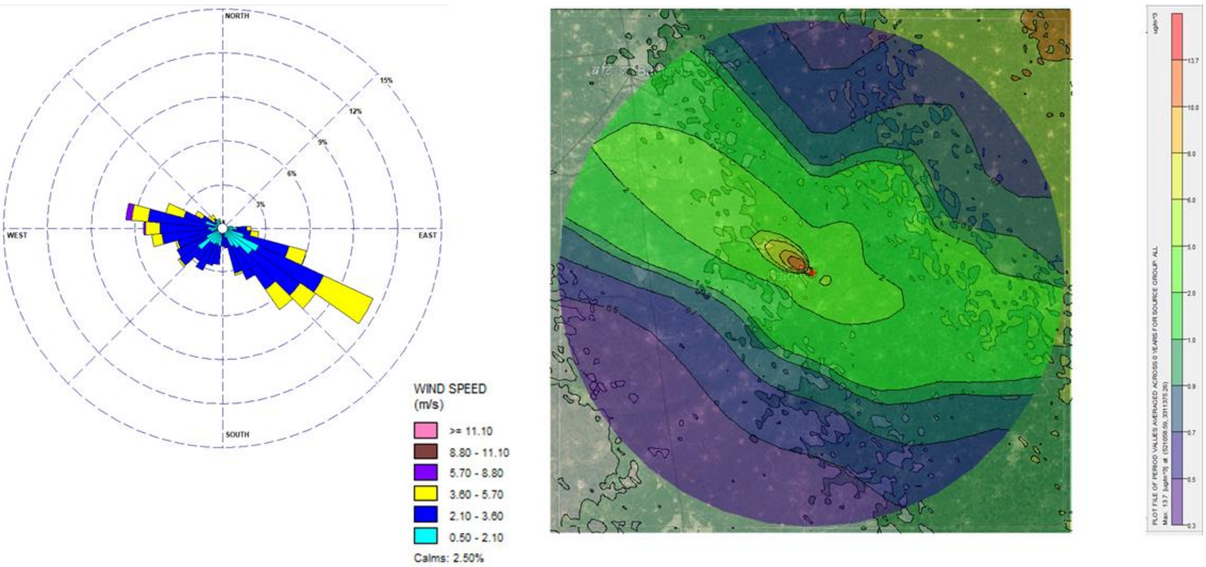


Figure 21 SO_2 Average Conc. for April Month

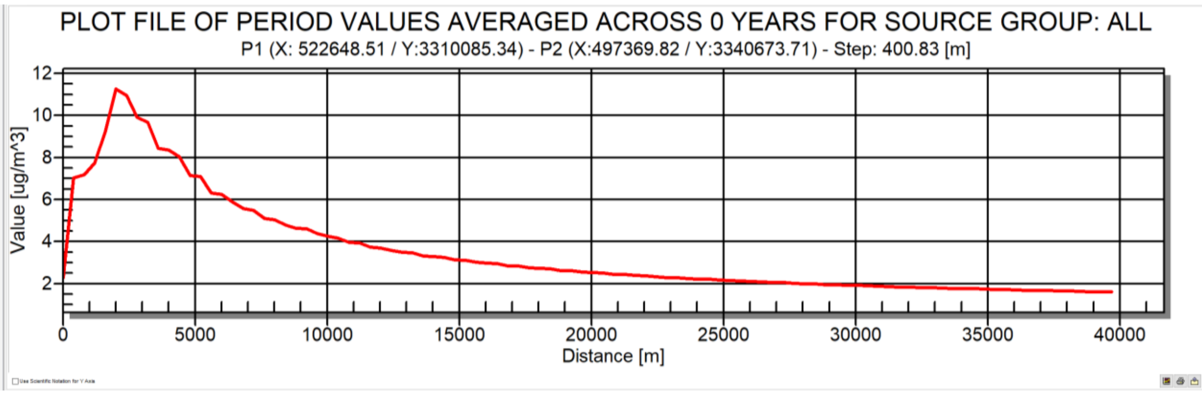


Figure 22 SO_2 Average Conc. Cross Section towards Bhatinda

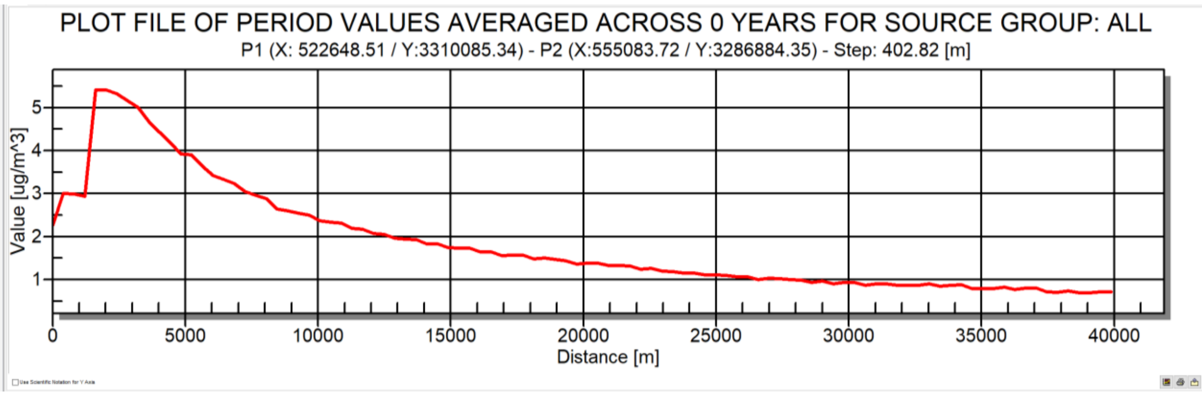


Figure 23 SO_2 Average Conc. Cross Section towards Delhi

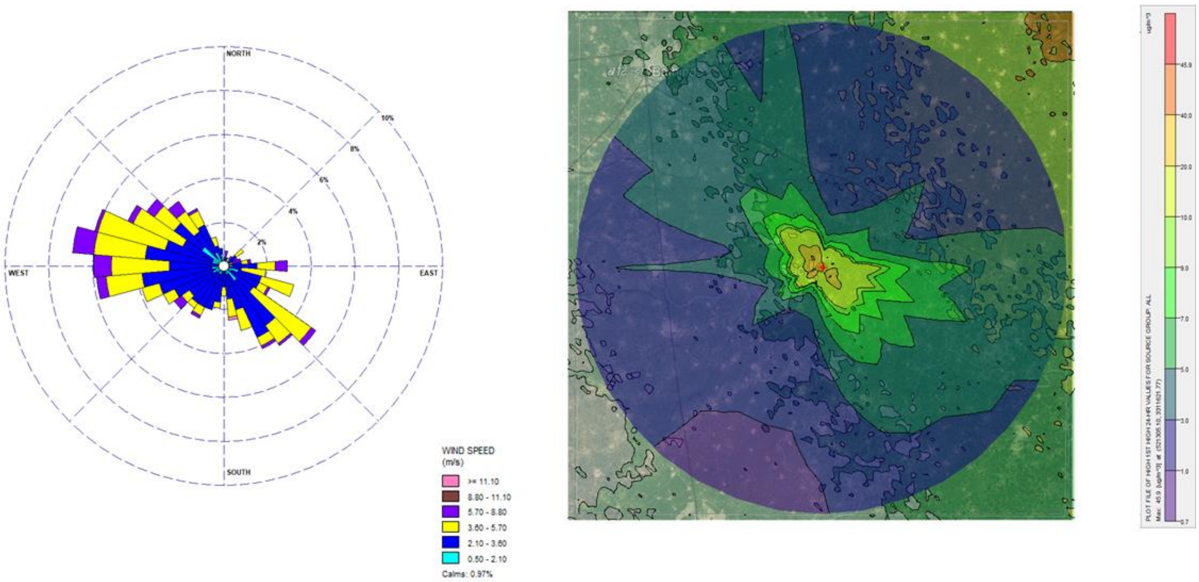


Figure 24 SO_2 1st Highest Conc. for April Month

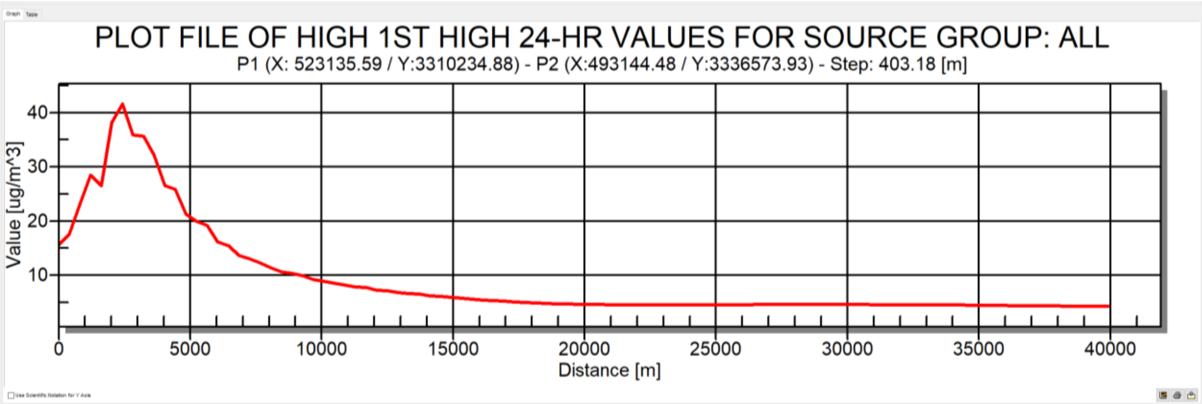


Figure 25 SO_2 1st Highest Conc. Cross Section towards Bhatinda

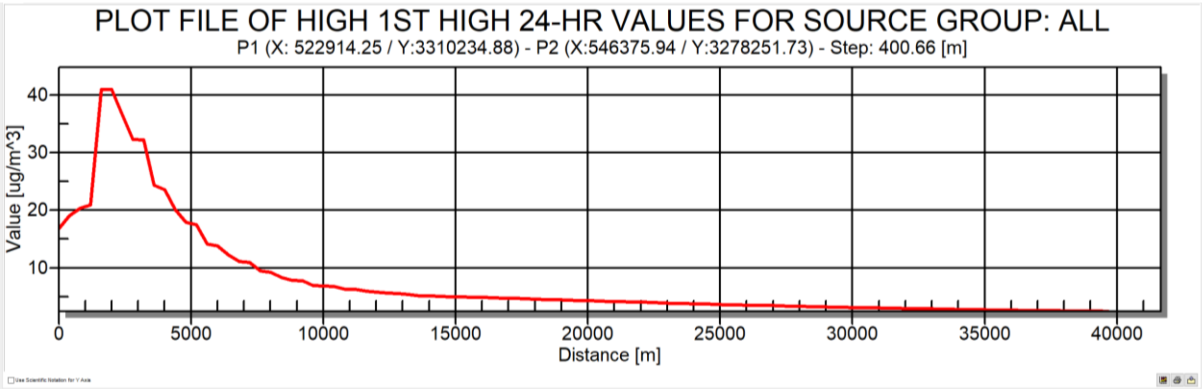


Figure 26 SO_2 1st Highest Conc. Cross Section towards Delhi

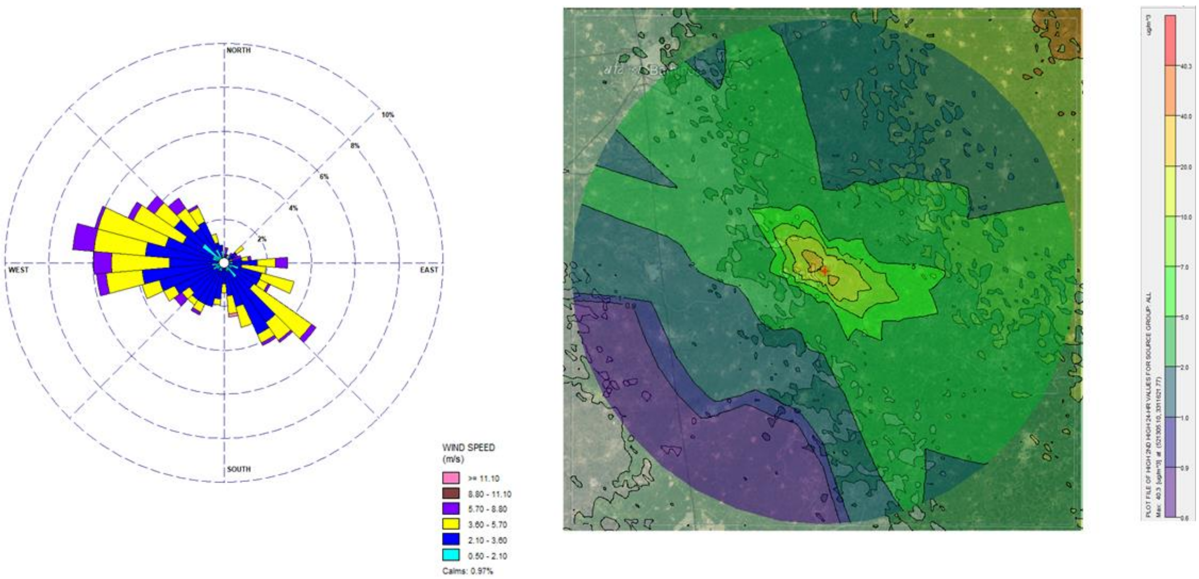


Figure 27 SO_2 2nd Highest Conc. for April Month

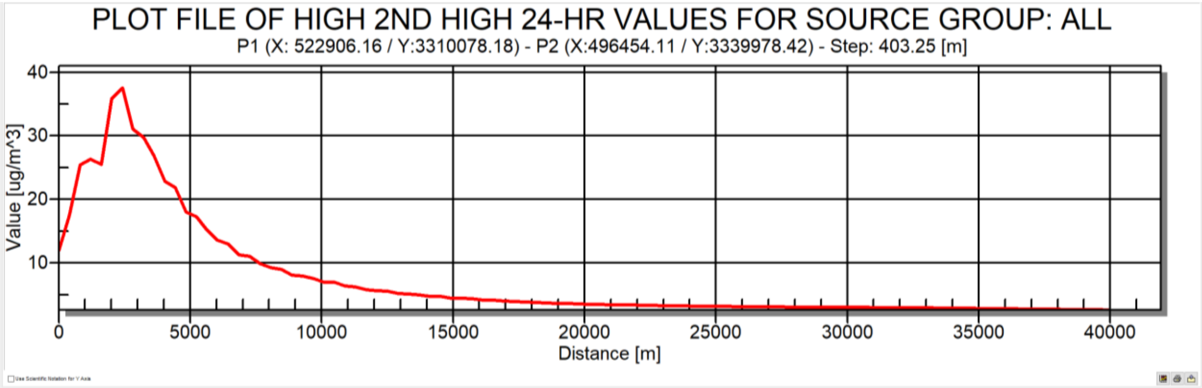


Figure 28 SO_2 2nd Highest Conc. Cross Section towards Bhatinda

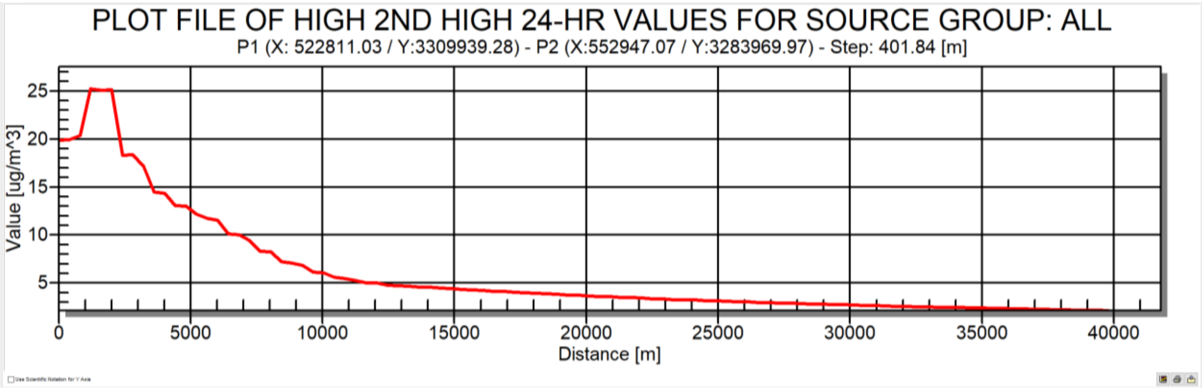


Figure 29 SO_2 2nd Highest Conc. Cross Section towards Delhi

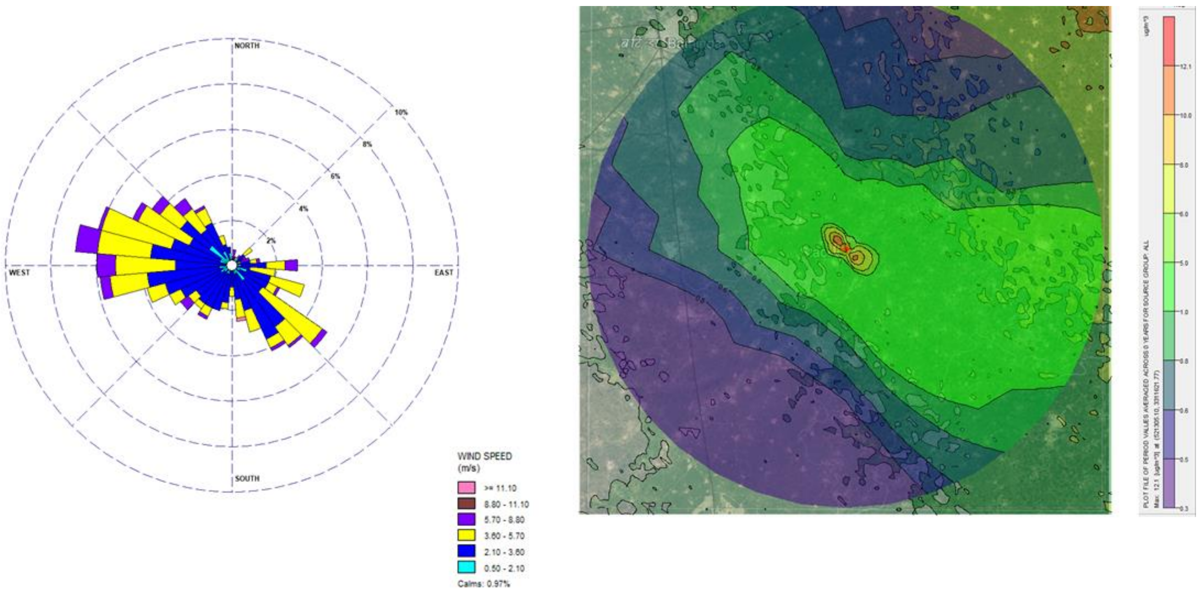


Figure 30 SO_2 Average Conc. for April Month

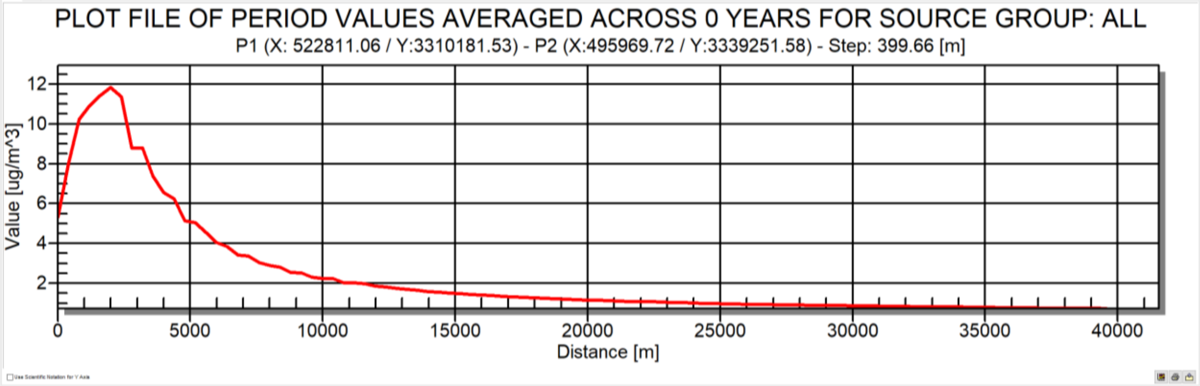


Figure 31 SO_2 Average Conc. Cross Section towards Bhatinda

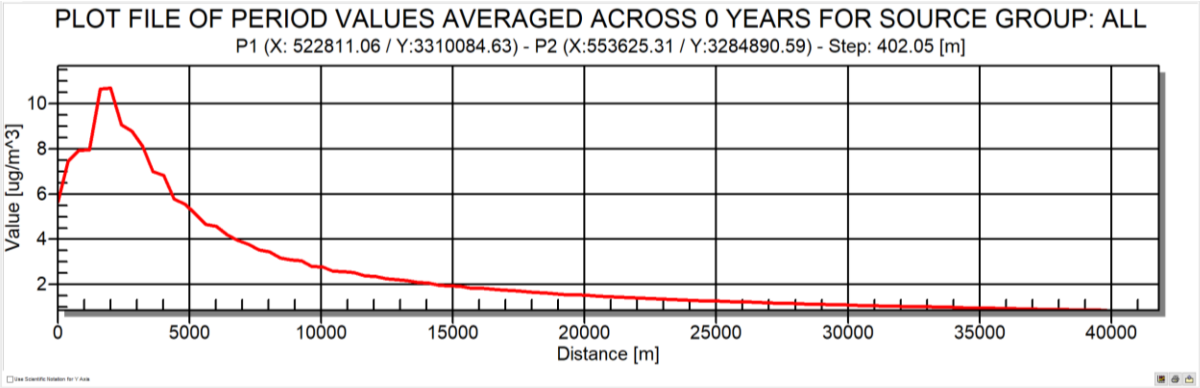


Figure 32 SO_2 Average Conc. Cross Section towards Delhi

The air quality modeling results for NO_2 from Talwandi Sabo Power Plant is presented in Table 3. The peak concentration varies from 29.2 to 52.1 µg/m3.

Table 3 NO_2 Air Quality Modeling results of Talwandi Sabo Power Plant

Month	Peak Concentration (µg/m^3)	Average Concentration (µg/m^3)
December	29.2	9.31
January	33.6	14.6
April	52.1	12.9

The peak and average concentration at different locations (distance) are presented in Table 4:

Table 4 NO_2 results at distances towards direction of Delhi of Talwandi Sabo Power Plant

Month	SO_2 (μg/m^3)	10km	20km	30km	40km	Beyond 40km	Date
December	Peak Concentration	12	8	6	4	<4	12-12-2018
	Average Concentration	4	3	1.5	1	<1	-
January	Peak Concentration	14	9	6	4	<4	31-01-2018
	Average Concentration	2.5	1.5	1	0.8	<0.8	-
April	Peak Concentration	10	5	2	0	0	22-04-2018
	Average Concentration	3	1.5	0.5	0	0	-

The wind rose & Iso-concentration graph of NO_2 and central line GLC and terrain contour is shown in Figure 33 to 59.

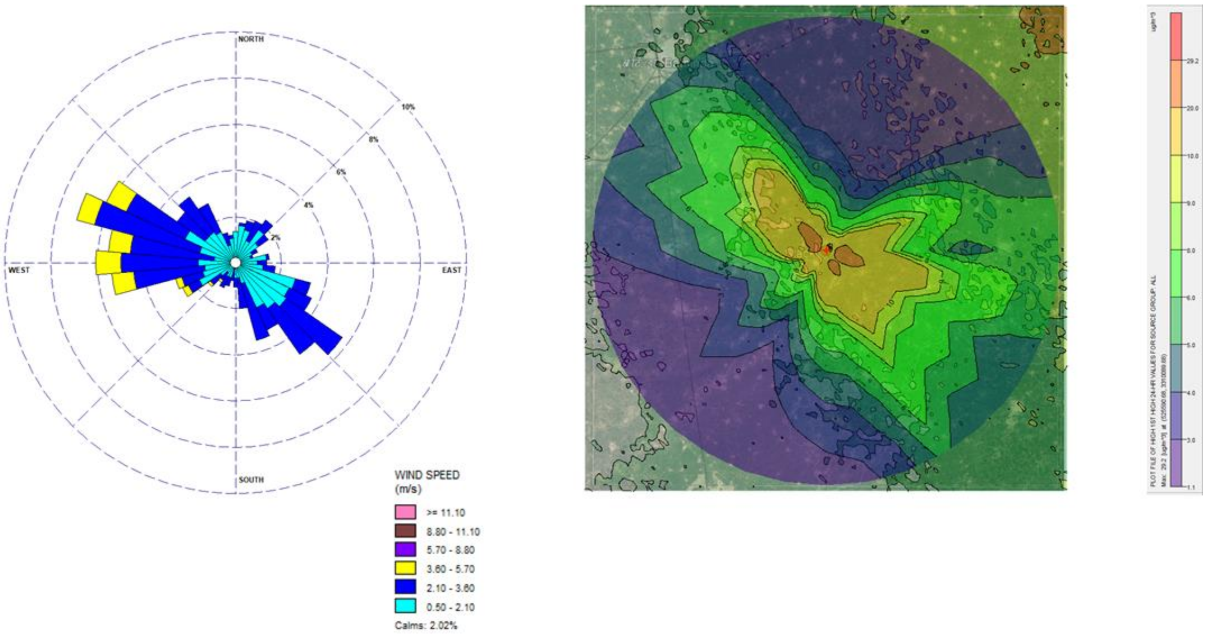


Figure 33 NO_2 1st Highest Conc. for December Month

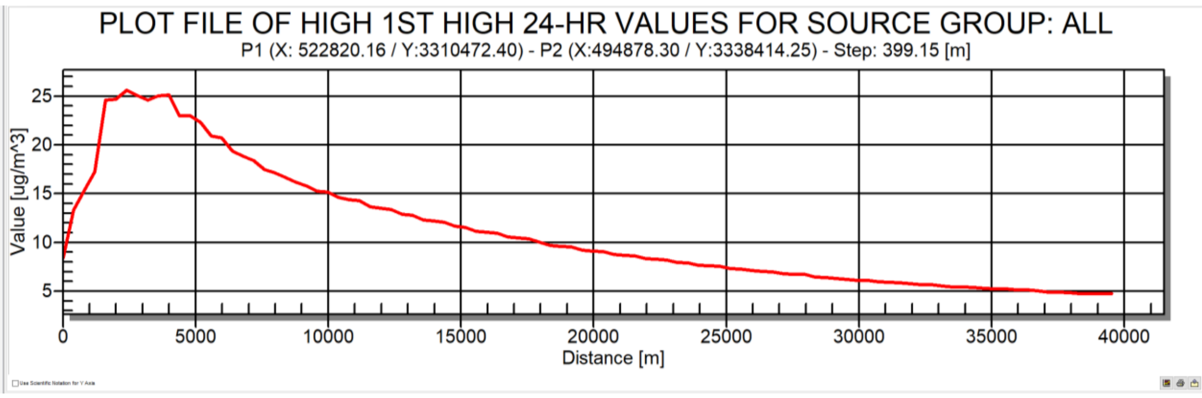


Figure 34 NO_2 1st Highest Conc. Cross Section towards Bhatinda

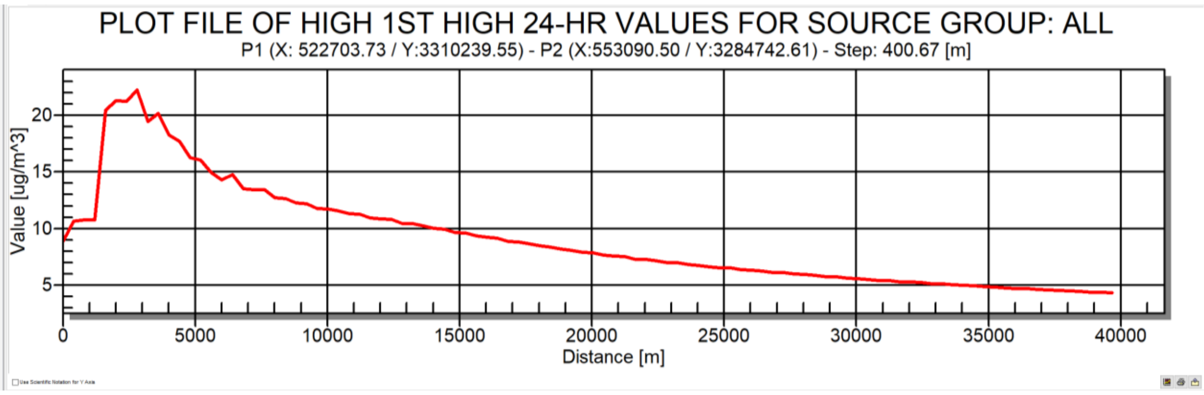
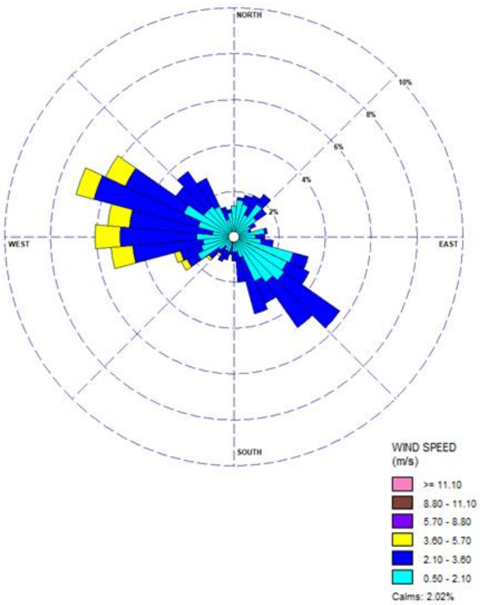


Figure 35 NO_2 1st Highest Conc. Cross Section towards Delhi



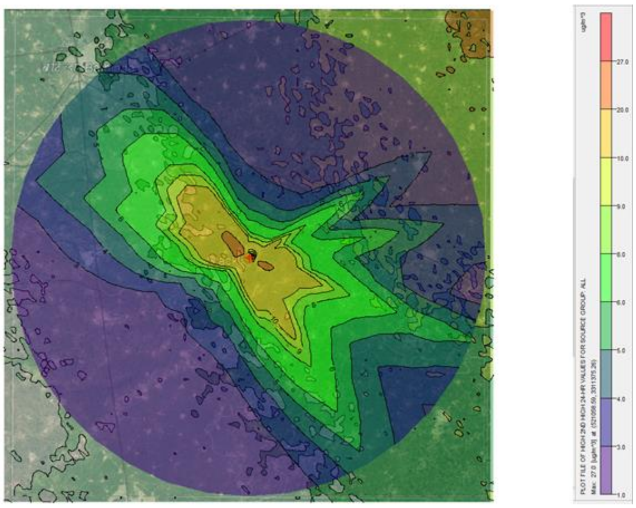


Figure 36 NO_2 2nd Highest Conc. for December Month

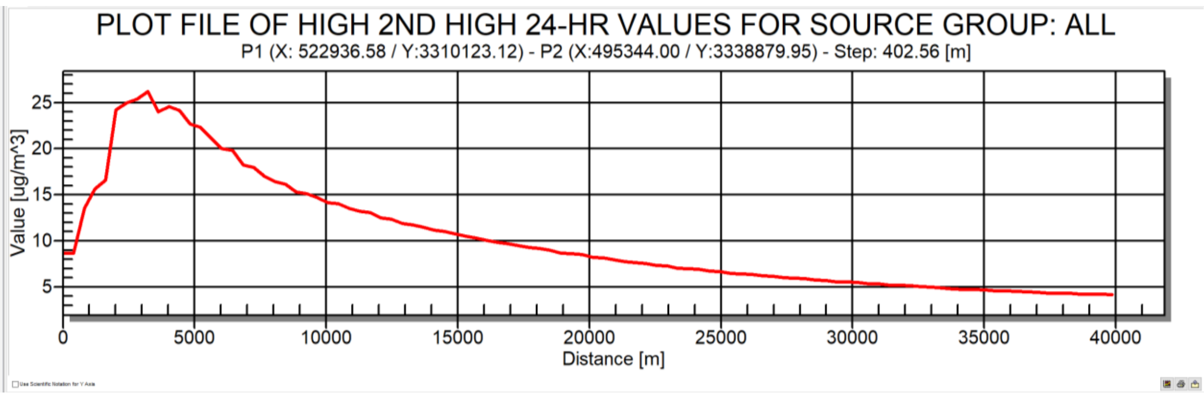


Figure 37 NO_2 2nd Highest Conc. Cross Section towards Bhatinda

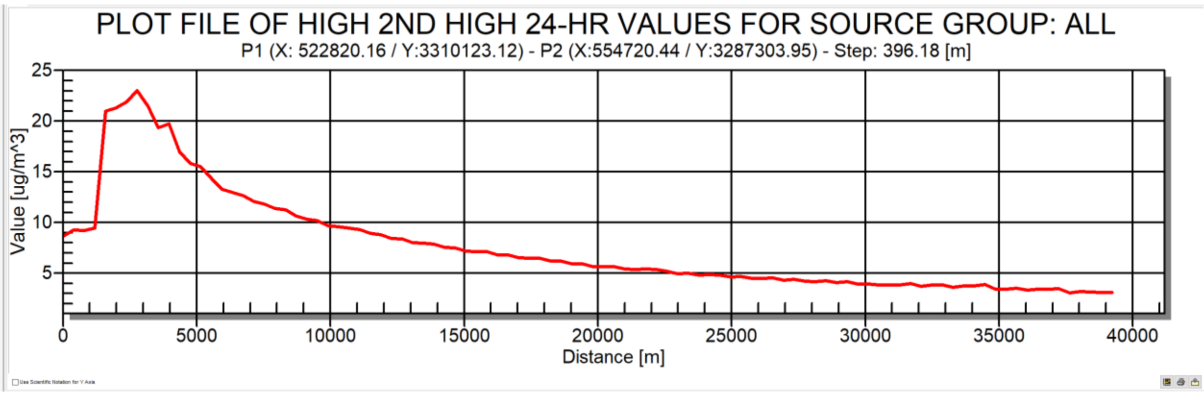


Figure 38 NO_2 2nd Highest Conc. Cross Section towards Delhi

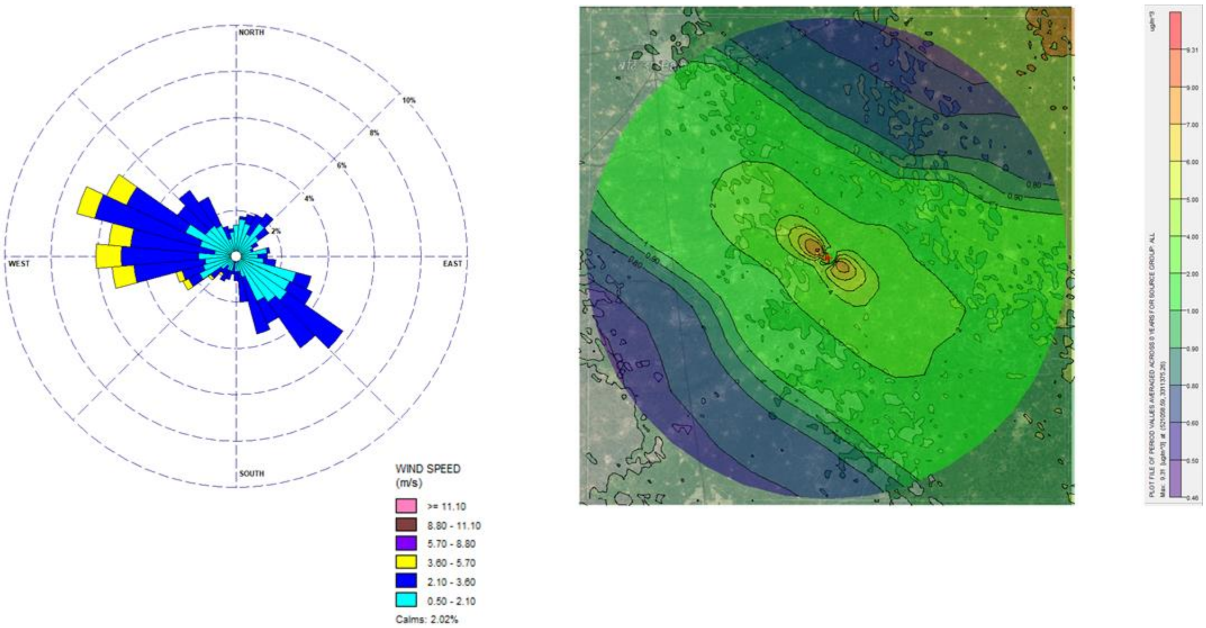


Figure 39 NO_2 Average Conc. for December Month

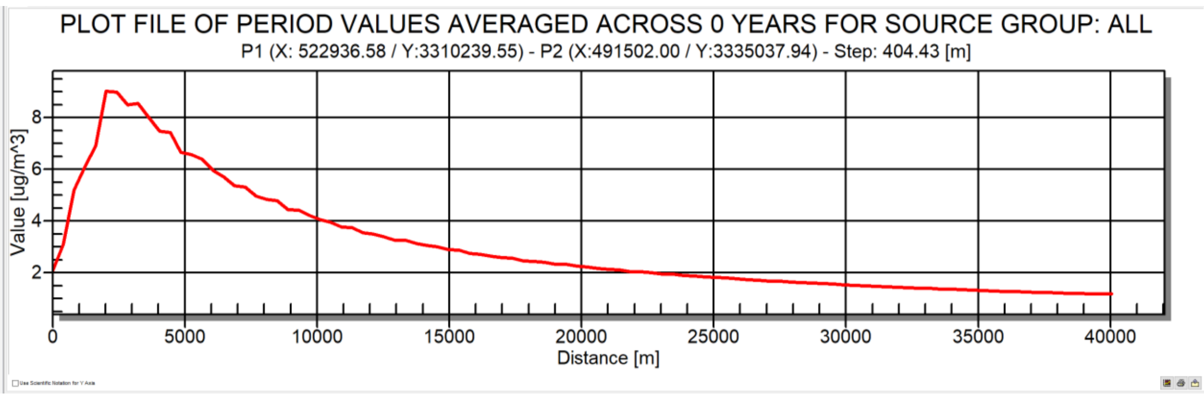


Figure 40 NO_2 Average Conc. Cross Section towards Bhatinda

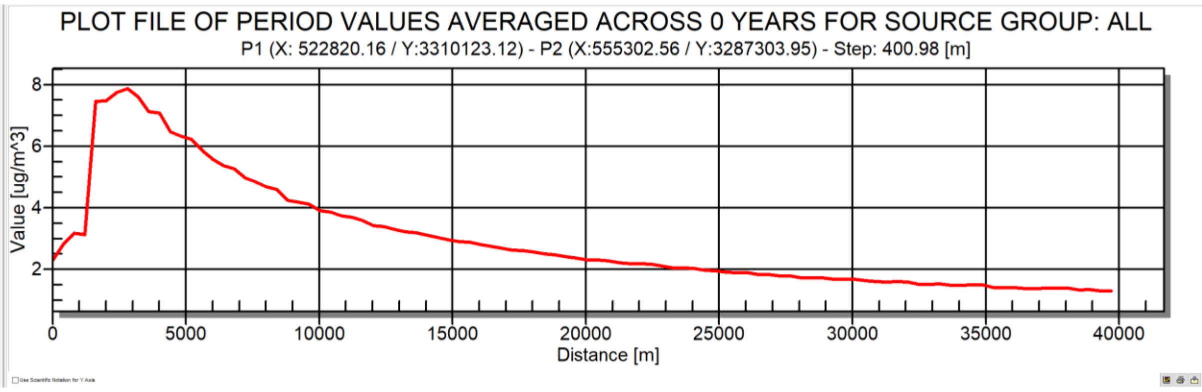


Figure 41 NO_2 Average Conc. Cross Section towards Delhi

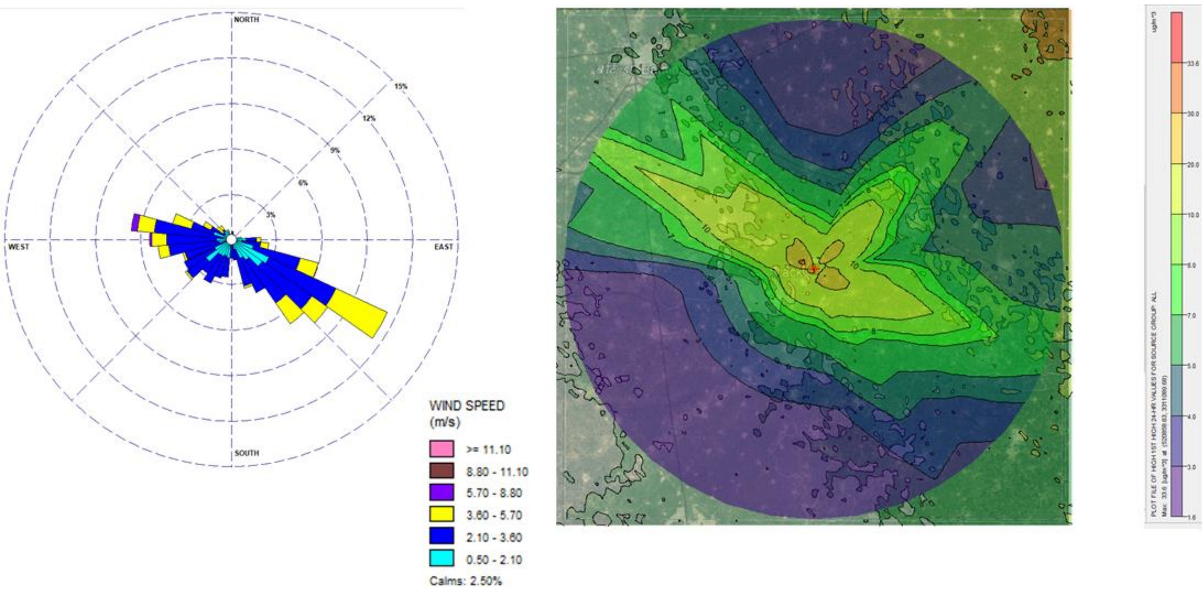


Figure 42 NO_2 1st Highest Conc. for January Month

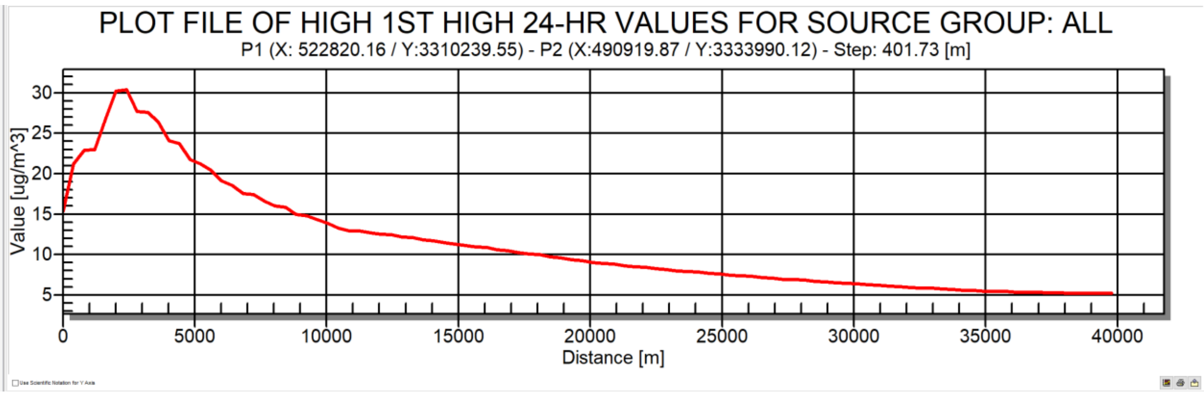


Figure 43 NO_2 1st Highest Conc. Cross Section towards Bhatinda

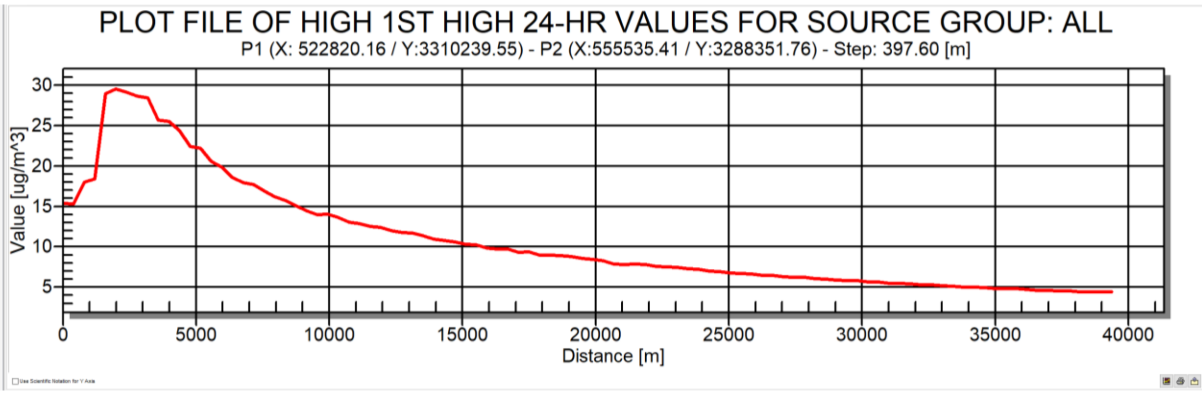


Figure 44 NO_2 1st Highest Conc. Cross Section towards Delhi

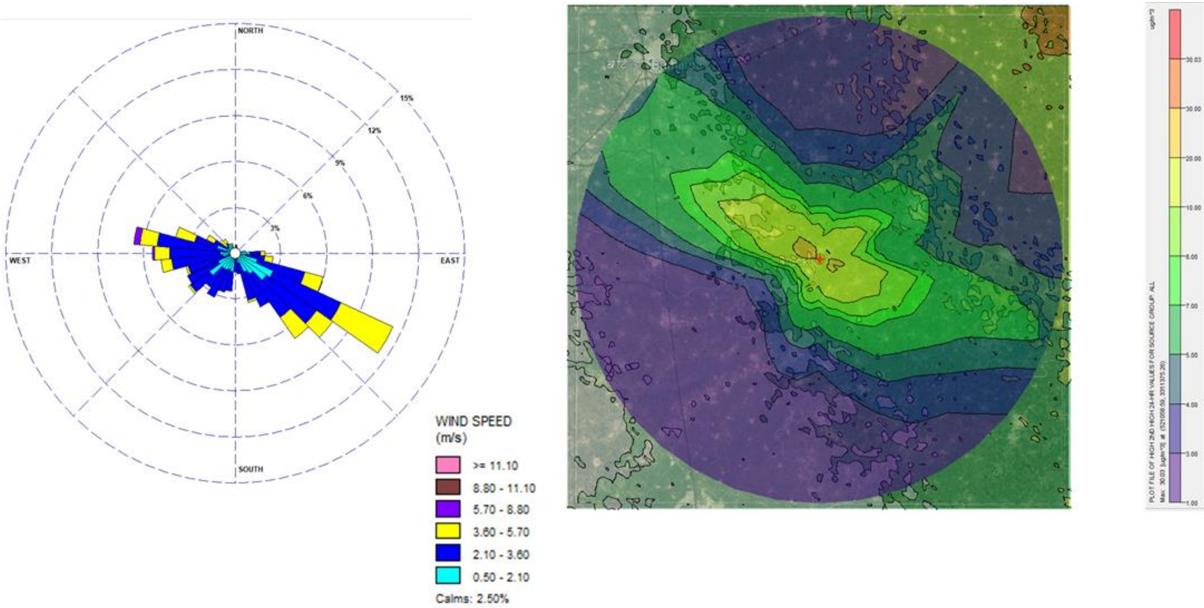


Figure 45 NO_2 2nd Highest Conc. for January Month

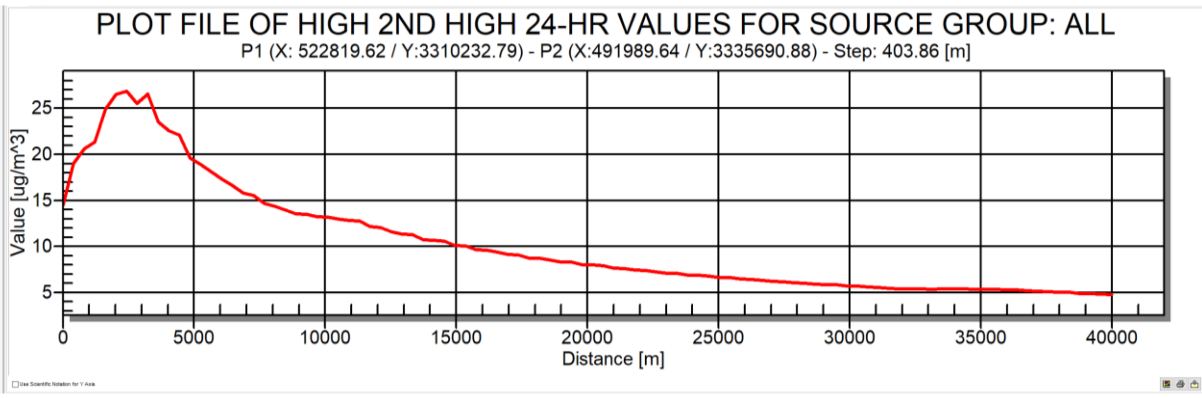


Figure 46 NO_2 2nd Highest Conc. Cross Section towards Bhatinda

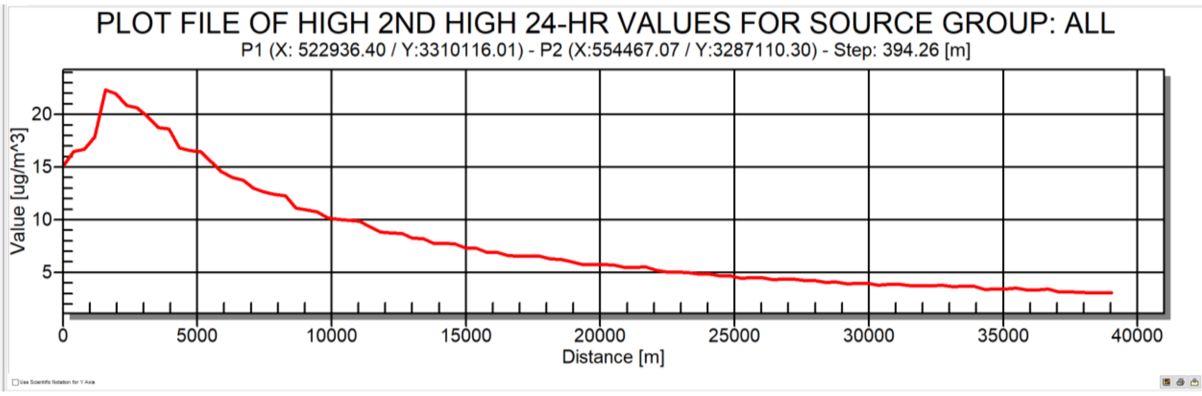


Figure 47 NO_2 2nd Highest Conc. Cross Section towards Delhi

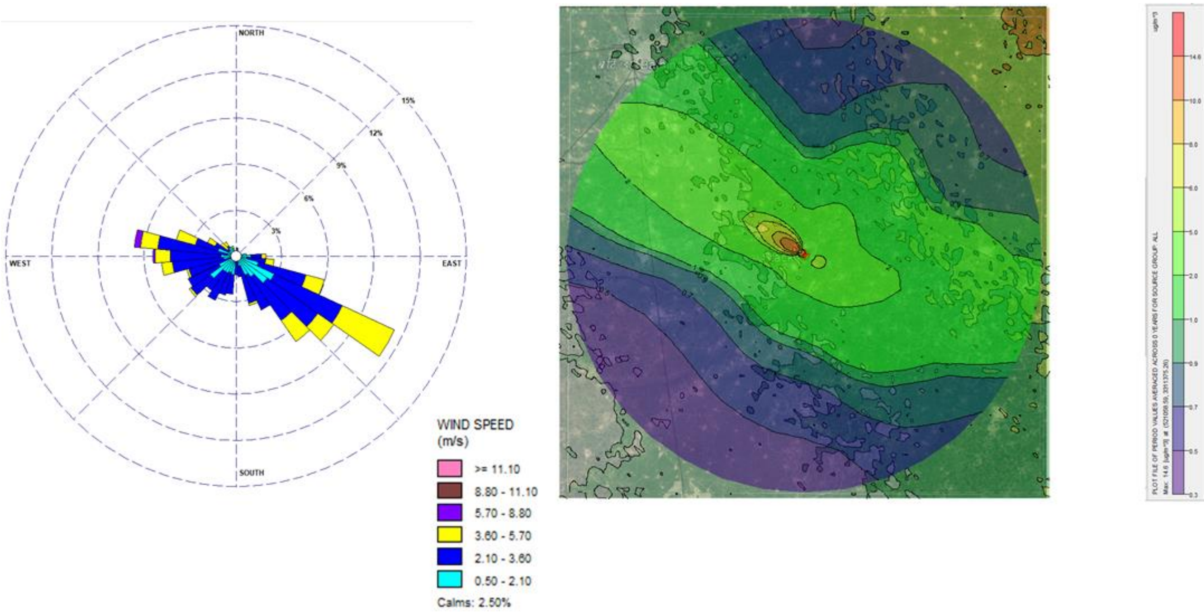


Figure 48 NO_2 Average Conc. for April Month

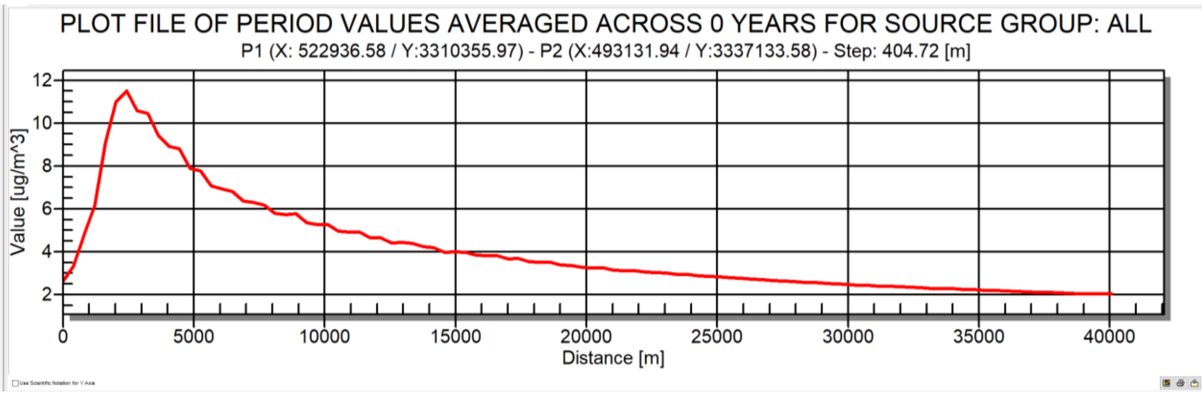


Figure 49 NO_2 Average Conc. Cross Section towards Bhatinda

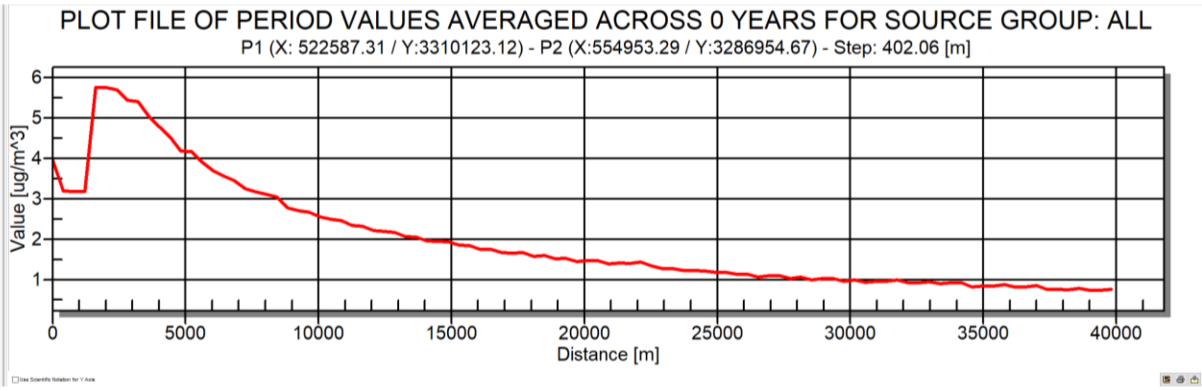


Figure 50 NO_2 Average Conc. Cross Section towards Delhi

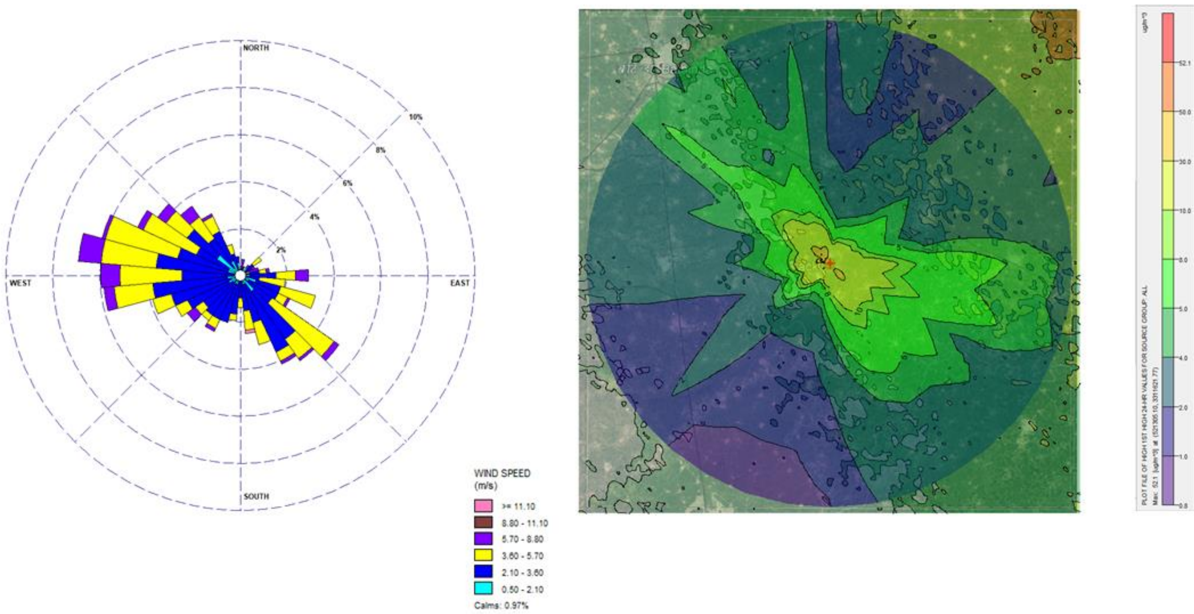


Figure 51 NO_2 1st Highest Conc. for April Month

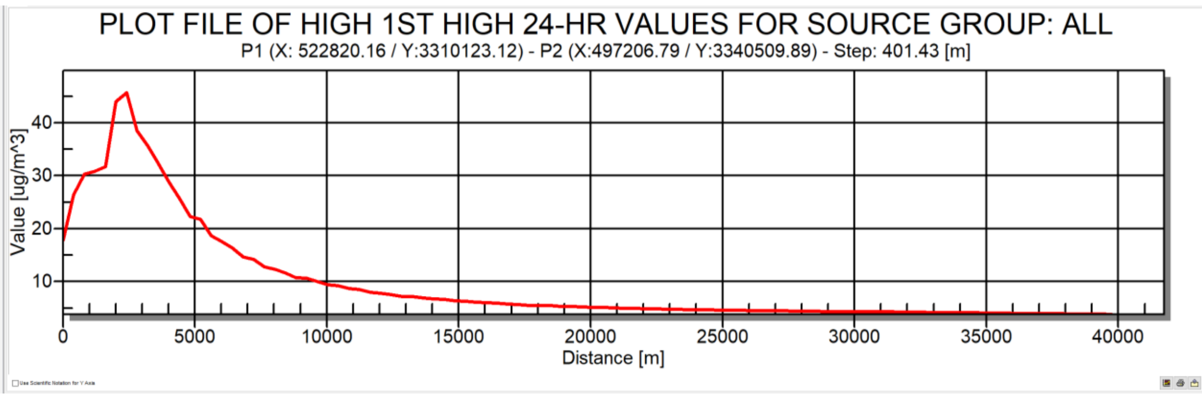


Figure 52 NO_2 1st Highest Conc. Cross Section towards Bhatinda

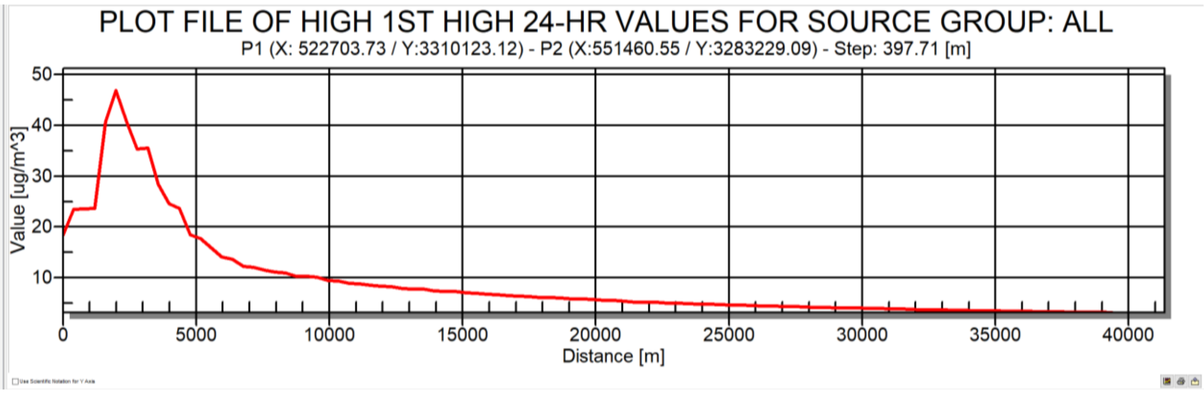


Figure 53 NO_2 1st Highest Conc. Cross Section towards Delhi

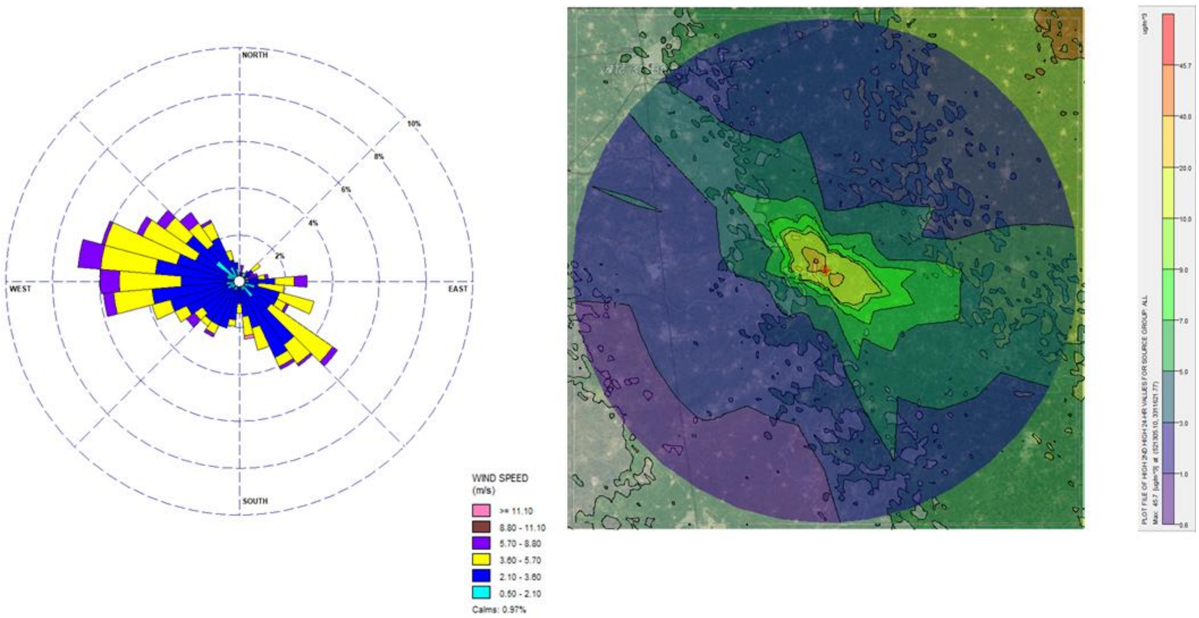


Figure 54 NO_2 2nd Highest Conc. for April Month

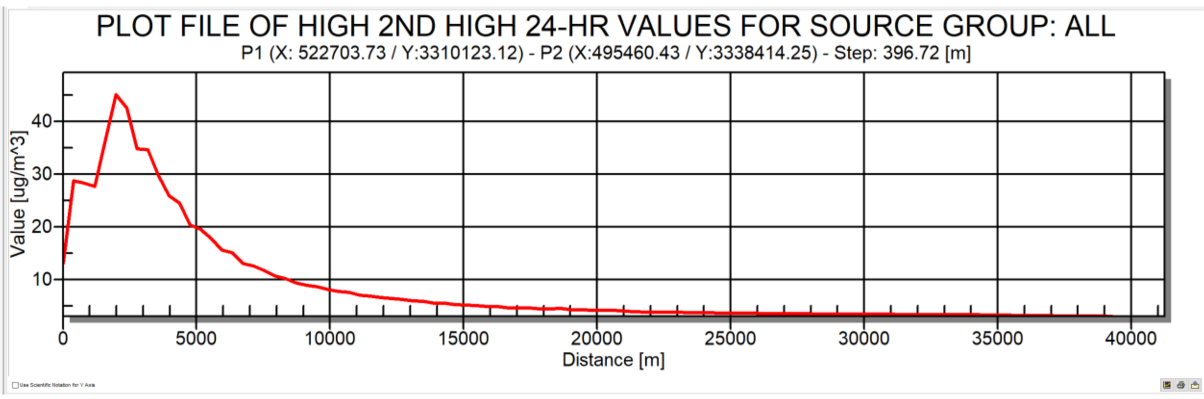


Figure 55 NO_2 2nd Highest Conc. Cross Section towards Bhatinda

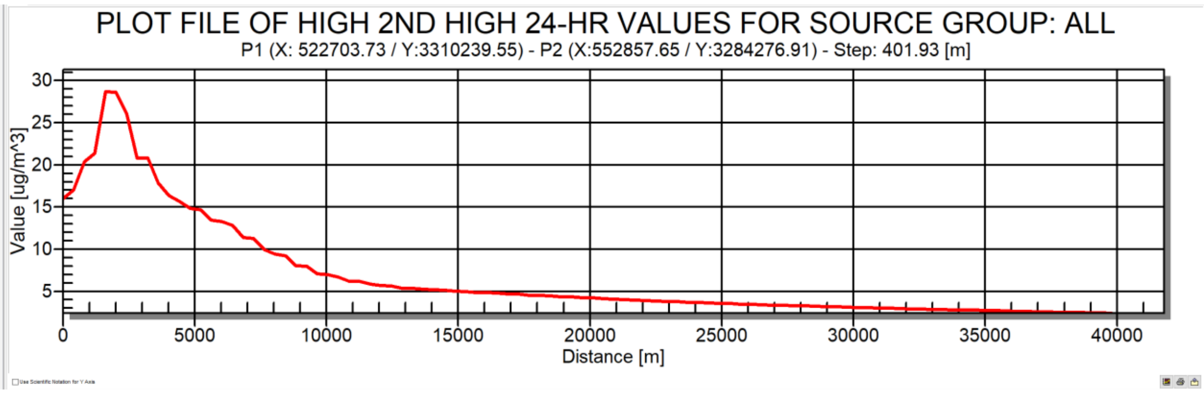


Figure 56 NO_2 2nd Highest Conc. Cross Section towards Delhi

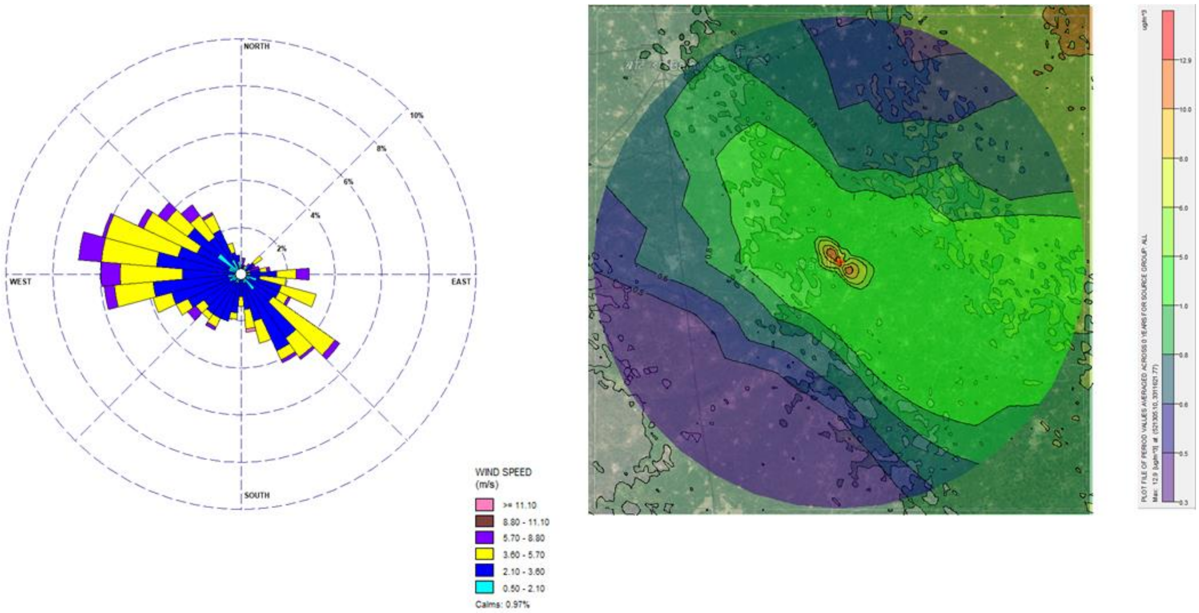


Figure 57 NO_2 Average Conc. for April Month

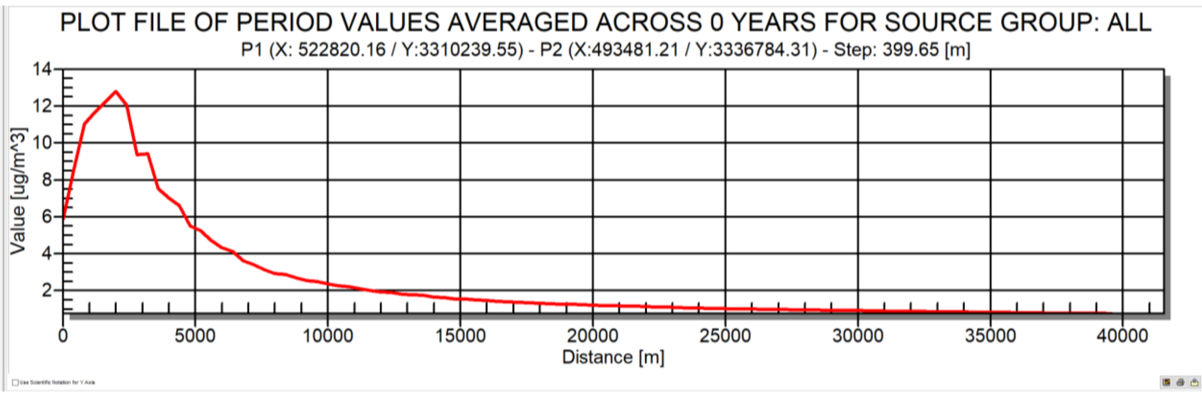


Figure 58 NO_2 Average Conc. Cross Section towards Bhatinda

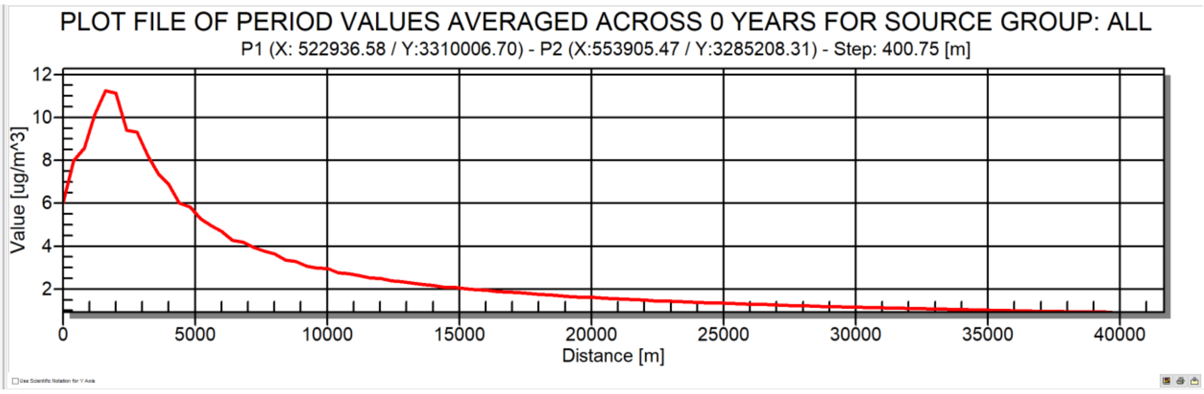


Figure 59 NO_2 Average Conc. Cross Section towards Delhi

11. Methodology for WRF-Chem modeling

In this study, emissions from Talwandi power plant and their resultant effects at a distant place like New Delhi were analyzed using Weather Research Forecasting (WRF)-Chem model. The total area to be analyzed was encapsulated into a gridded format enclosing both, the site of the power plant and Delhi as well. For the purpose, the central point coordinate of domain is lat: 29.0588 N, lon: 76.0856 E. The grid size was taken as 4km×4km (domain size is 400 km×400km).

To analyses the formation of SO_4 (sulfates), and NO_3 (Nitrates), anthropogenic emissions from the plant were considered. The plant emissions for SO_2 and NO_2 were edited in base file of EDGAR-HTAP emission inventory (global) in the respective grid and all other emissions were considered zero. The modelling also requires emission of ammonia; the default emission from EDGAR-HTAP was taken.

ARWpost was used to extract graphical and numerical data. Data was formulated into a tabular format along with their graphical outputs showing weekly and monthly mean and maximum concentrations each for SO_4 (sulfates) and NO_3 (Nitrates). Also, a time series analysis for concentrations of each parameter was also extracted out both at the plant site as well as at Delhi. The visualization tool used here for displaying the graphical outputs was GrADS.

12. Results and Discussion on WRF-Chem Modeling

For WRF-Chem modelling of sulfate and nitrate, the critical month of November (2018) has been selected. The results and interpretation of model output are presented below.

Although in the FY 2018-19, the plant load factor is 61.34%, however, to obtain maximum impact, which may occur during full load operation, all modelling results pertain to full load of the plant.

SO_4 and NO_3 Concentration in November 2018 (Weekly)

Weekly mean concentrations were extracted from the model outputs using GrADS visualization tool for the plant site and were found to be reported in the following figures respectively for four consecutive weeks in the month of November with SO_4 and NO_3 concentrations (Figures 60–67).

Sulfate levels increase as one moves from the plant site up to 100 km towards S-E direction showing peak levels of 0.40 - 0.90 µg/m^3. It may be noted that S-E is the prevailing downwind direction from the plant and impact is seen for a long distance. However, at a distance of about 250 km (in S-E) the levels are dropped nearly by 60% to 0.18 – 0.30 µg/m^3. It may be noted that S-E is the prevailing downwind direction from the plant and sulfate impact is seen for a long distance.

Weekly nitrate levels have shown increased levels in S-E direction (0.06- 0.10 µg/m^3) at about 50-55 km compared to the levels very close to the plant site. However, at a distance of about 250 km (in S-E), the levels are at 0.01 µg/m^3. The levels are insignificant at 250 km.

SO_4 and NO_3 Concentration in the month of November (2018)

Like weekly sulfates levels above, the levels are high in S-E direction at about 40 km with mean monthly peak concentrations of 0.45 - 0.48 µg/m^3 (somewhat lower than peak weekly concentration). Nitrates show monthly peak concentration is 0.06 µg/m^3 towards S-E to as low as 0.01 µg/m^3 in the S-E direction (Figures 68 – 69).

Tables 5 and 6 summarize the concentrations of sulfate and nitrate as a function of distance in S-E direction for monthly.

The 24-hourly mean peak concentration of SO_4 was 2.18 µg/m^3 in the S-E direction at 12 km which drops to 0.73 µg/m^3 in S-E direction at a distance of about 250 km (Table 5). The 24-hourly mean peak concentration of NO_3 was 0.41 µg/m^3 in S-E direction at a distance of about 12 km and it drops to less than 0.002 µg/m^3 at a distance of about 250 km.

The peak air quality Index (AQI) in Delhi was about 500 during November 2018 which corresponds to 380 µg/m^3 of $PM_{2.5}$. Considering that 24-hr sulfate concentration contributed by plant at a distance of about 250 km(i.e. near Delhi) is 0.73 µg/m^3, that is about 0.2%.

Table 5: Sulfate concentration with distance towards S-E

Averaging time	**Sulfate concentration (µg/m^3) in a 4 km × 4 km Grid**					
	12 km	**50 Km**	**100 Km**	**150 Km**	**200 Km**	**250 Km**
Mean (monthly)	0.51	0.38	0.31	0.32	0.29	0.28
Max (24-hourly)	2.18	1.77	0.69	1.35	0.98	0.73
Minimum	0.15	0.14	0.14	0.14	0.14	0.14

Table 6: Nitrate concentration with distance towards S-E

Averaging time	**Nitrate concentration (µg/m^3) in a 4 km × 4 km Grid**					
	12 km	**50 Km**	**100 Km**	**150 Km**	**200 Km**	**250 Km**
Mean (monthly)	0.069	0.038	0.015	0.011	0.012	0.000
Max (24-hourly)	0.413	0.349	0.251	0.121	0.091	0.002
Minimum	0.000	0.000	0.000	0.000	0.000	0.000

1) Weekly Mean SO_4 Concentration:-

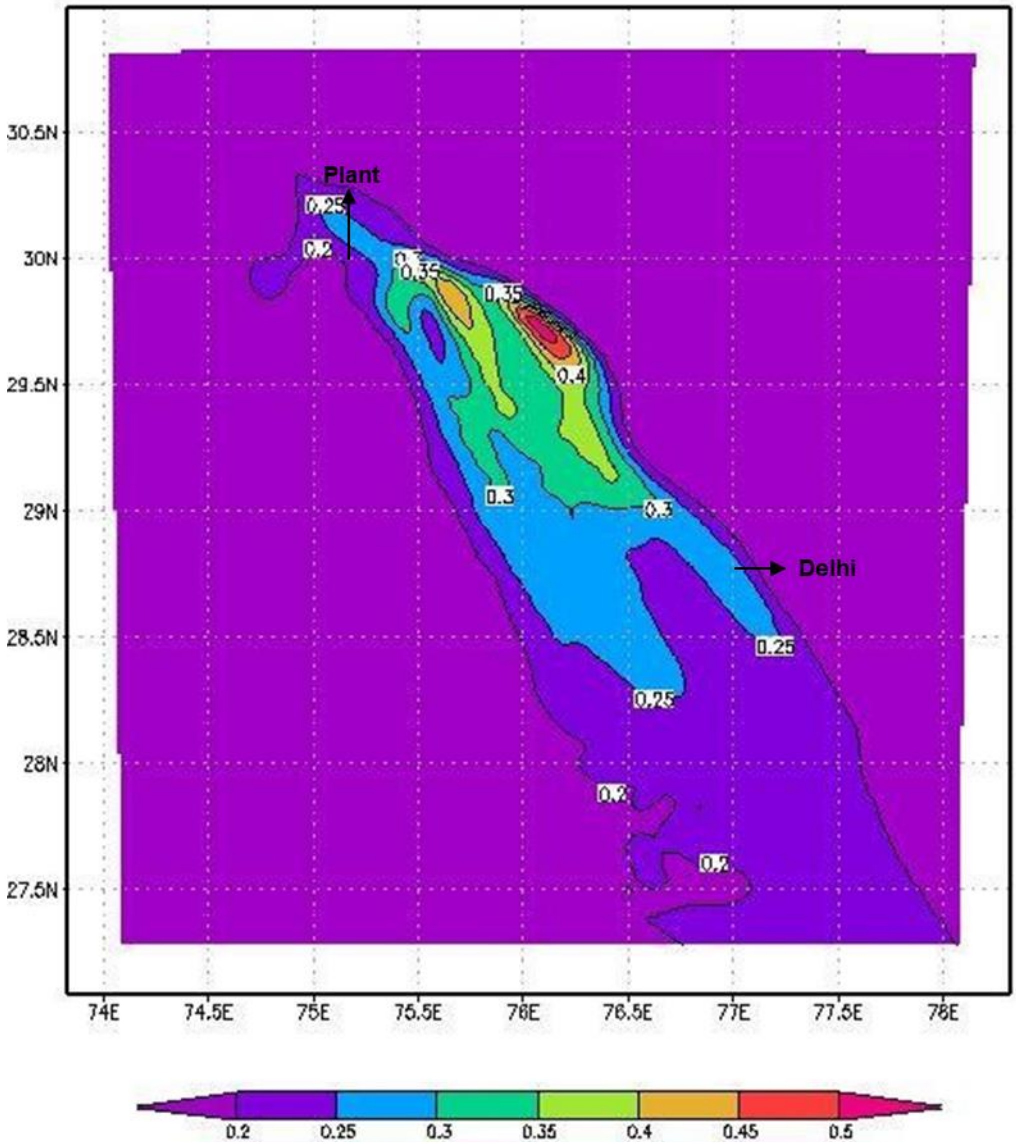


Figure 60: Weekly Mean SO_4 Concentration ($\mu g/m^3$) [1-7 Nov2018]

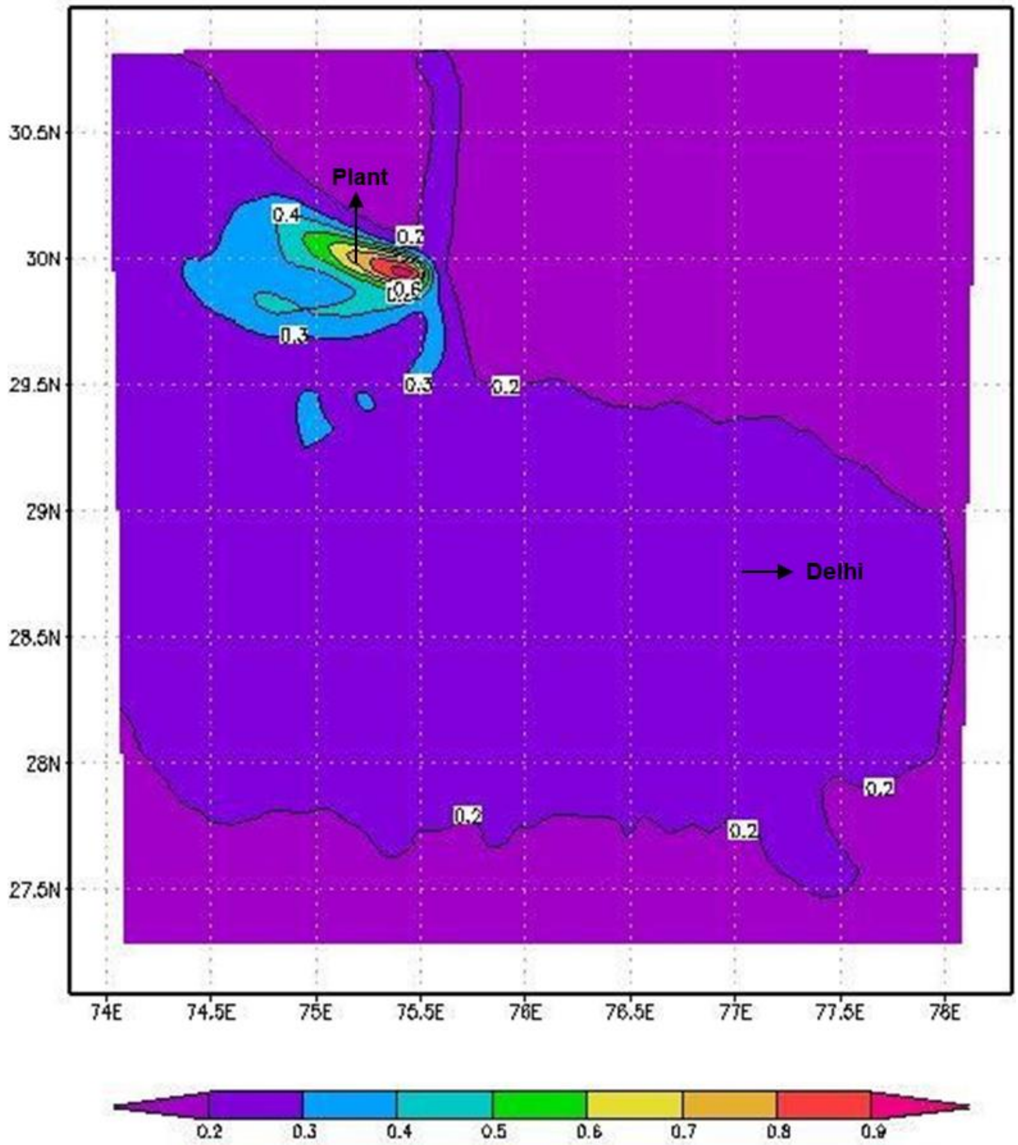


Figure 61:Weekly Mean SO_4 Concentration ($\mu g/m^3$) [8-15Nov2018]

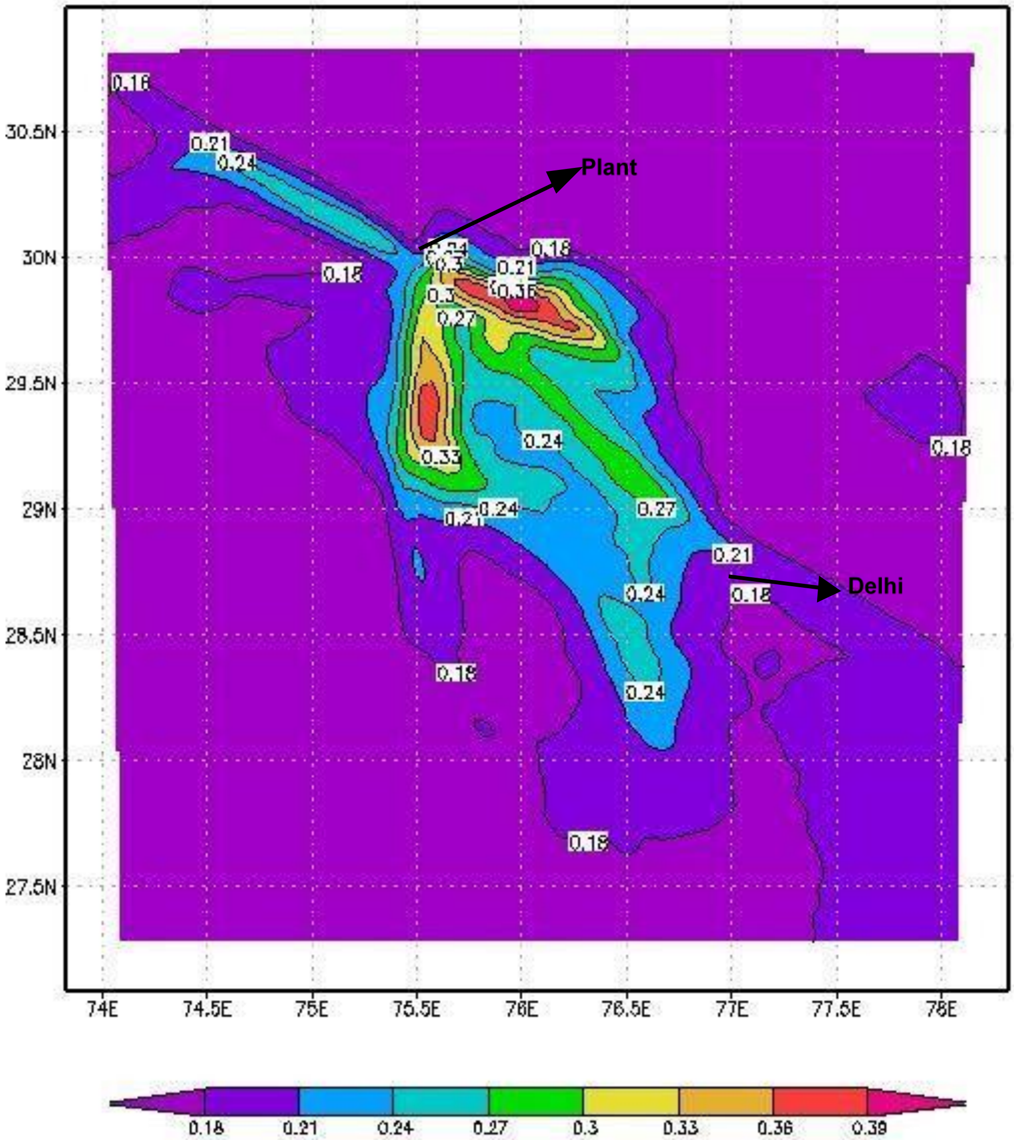


Figure 62: Weekly Mean SO_4 Concentration (µg/m^3) [16-23Nov2018]

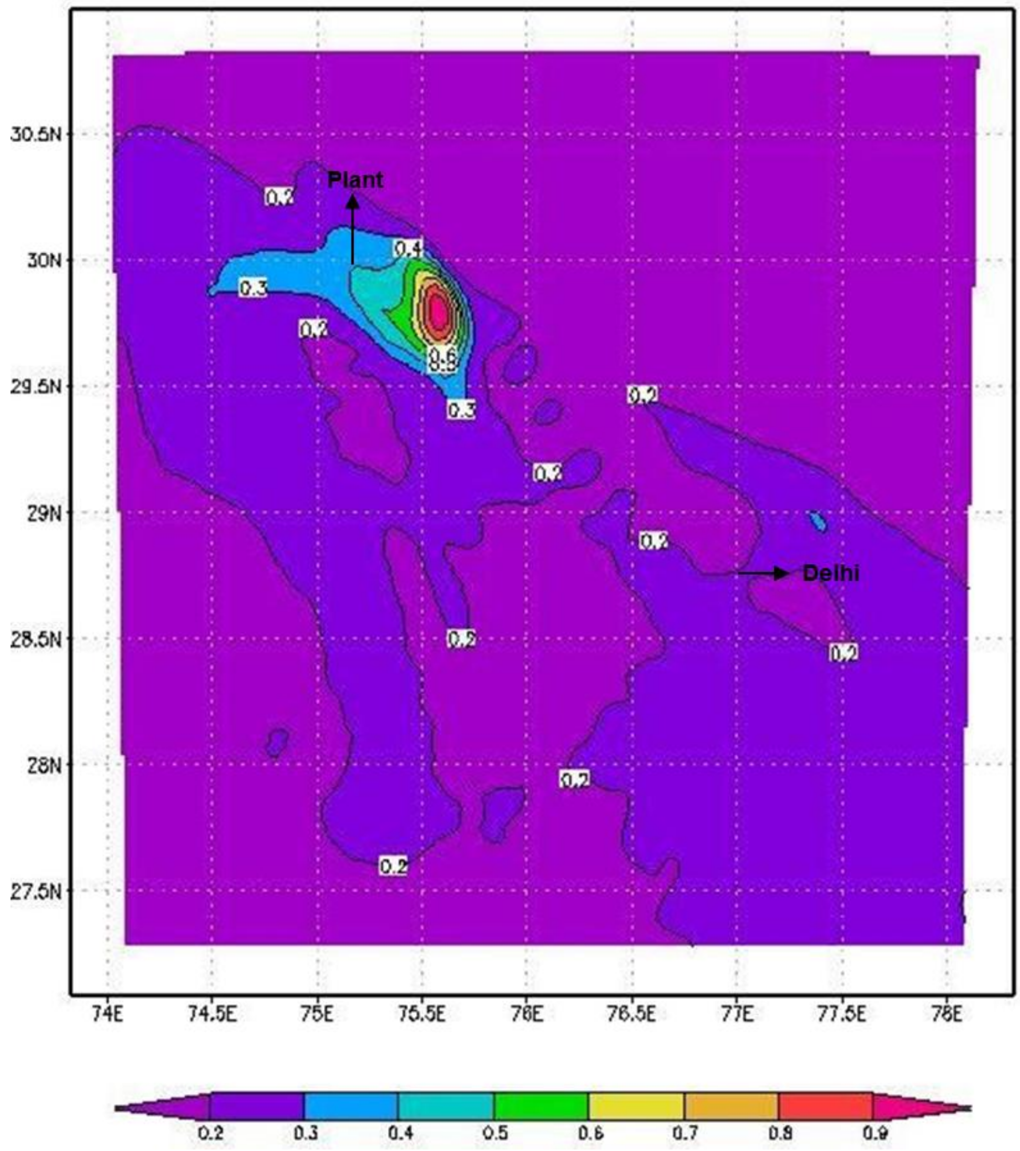


Figure 63: Weekly Mean SO_4 Concentration (μg/m^3) [24-30Nov2018]

2) **Weekly Mean NO_3 Concentration:-**

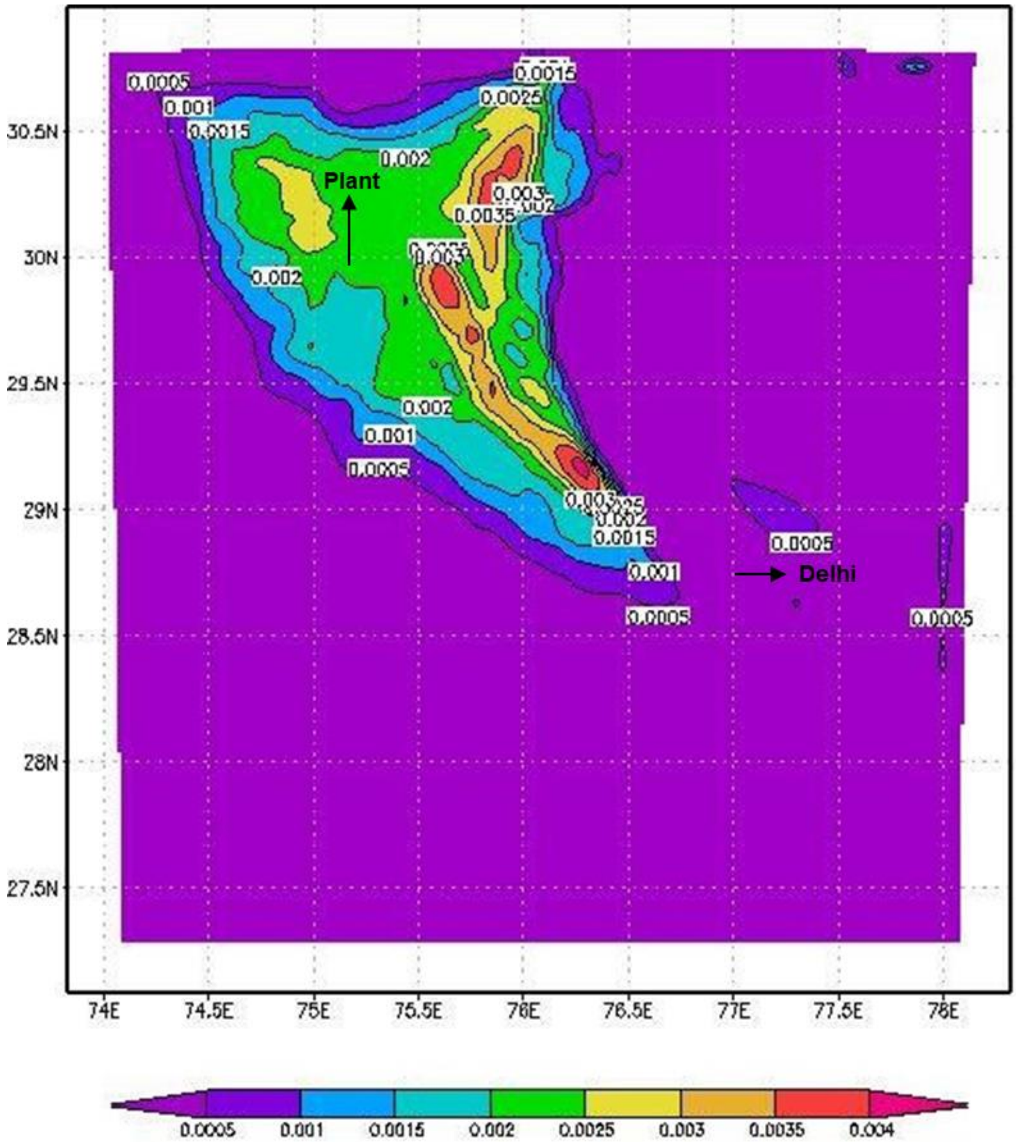


Figure 64: Weekly Mean NO_3 Concentration ($\mu g/m^3$) [1-7Nov2018]; use a multiplying factor of 16 for corrected concentrations

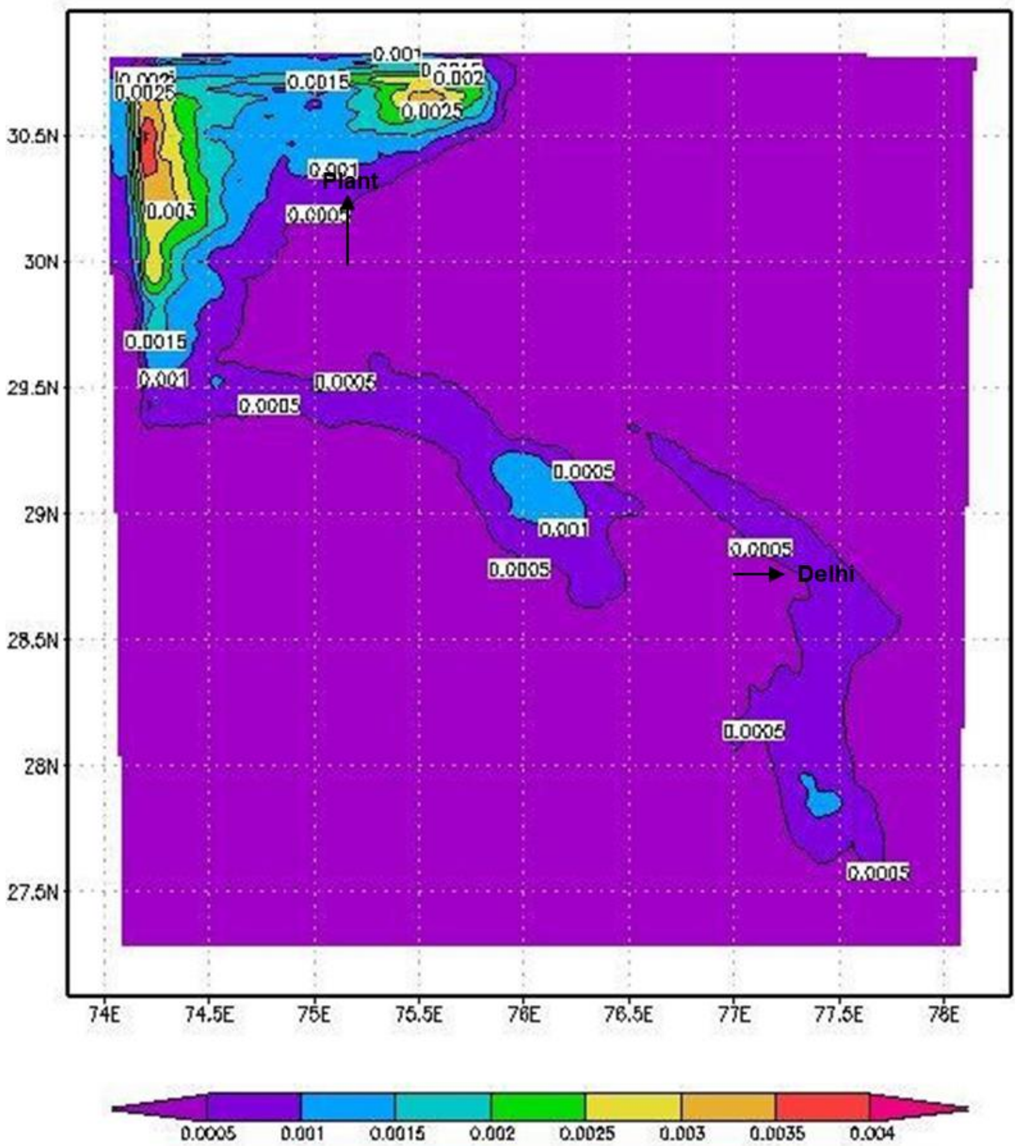


Figure 65: Weekly Mean NO_3 Concentration ($\mu g/m^3$) [8-15Nov2018]; use a multiplying factor of 16 for corrected concentrations

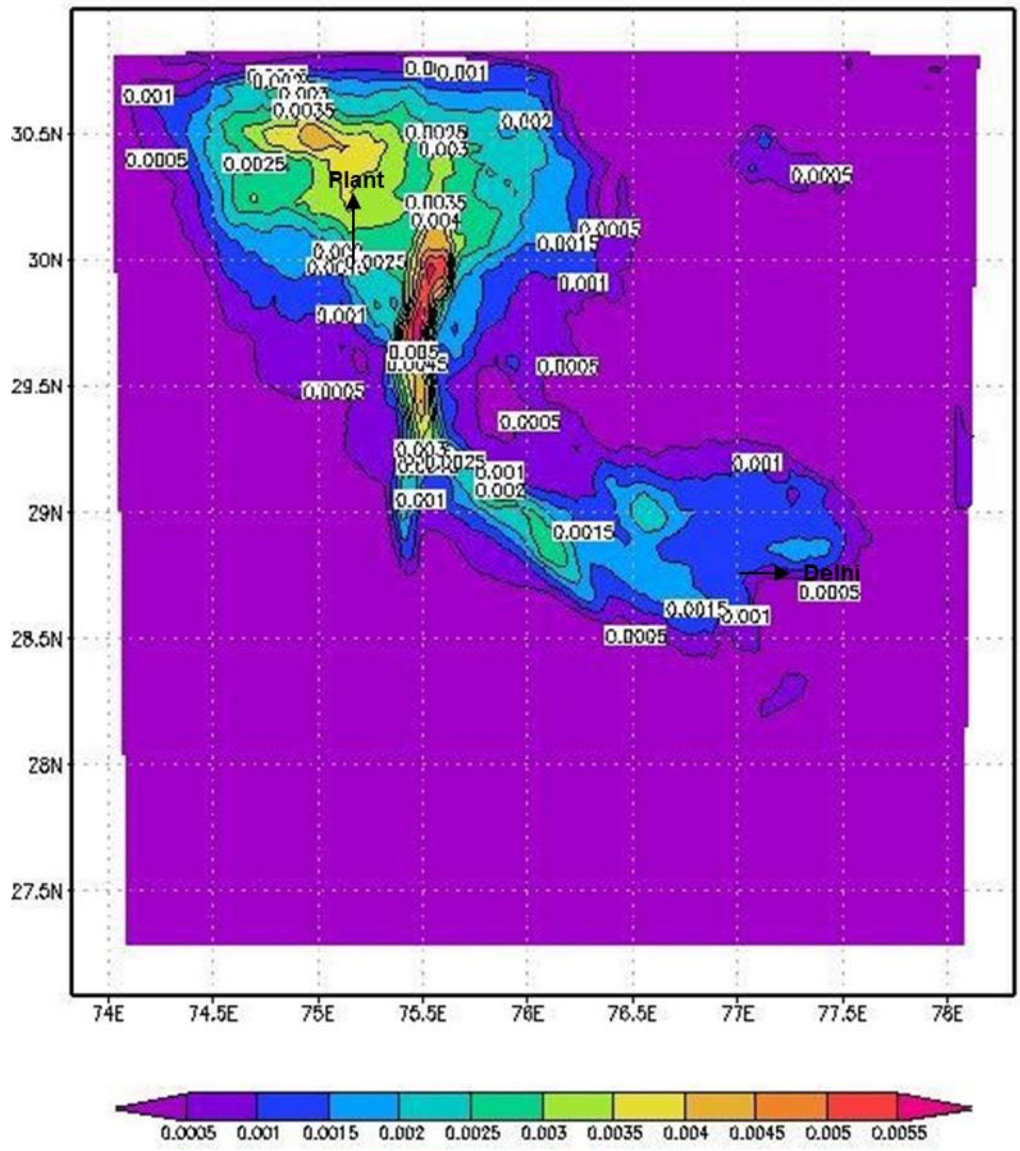


Figure 66: Weekly Mean NO_3 Concentration ($\mu g/m^3$) [16-23Nov2018]; use a multiplying factor of 16 for corrected concentrations

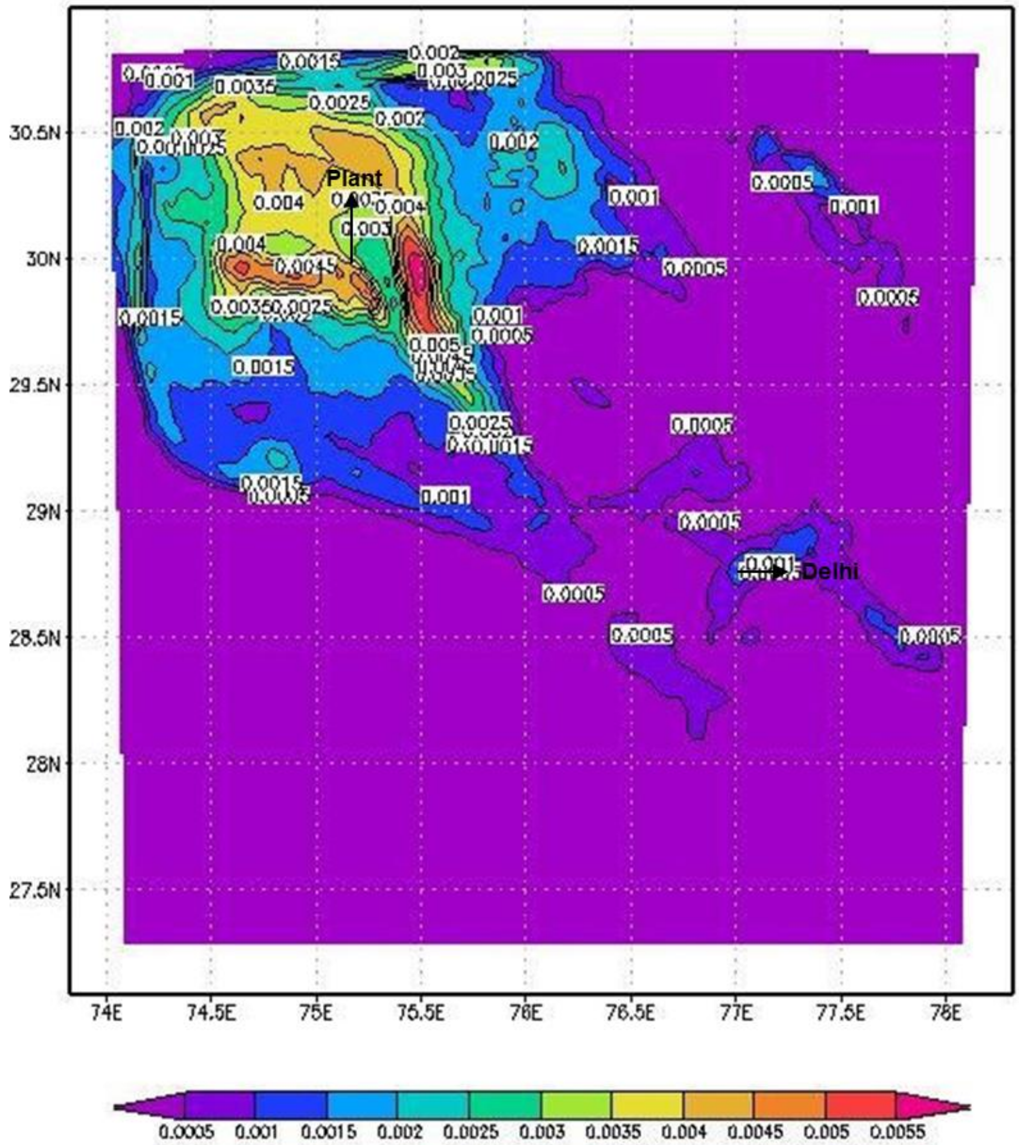


Figure 67: Weekly Mean NO_3 Concentration (µg/m^3) [24-30Nov2018]; use a multiplying factor of 16 for corrected concentrations

3) **Monthly Mean Concentration** :-

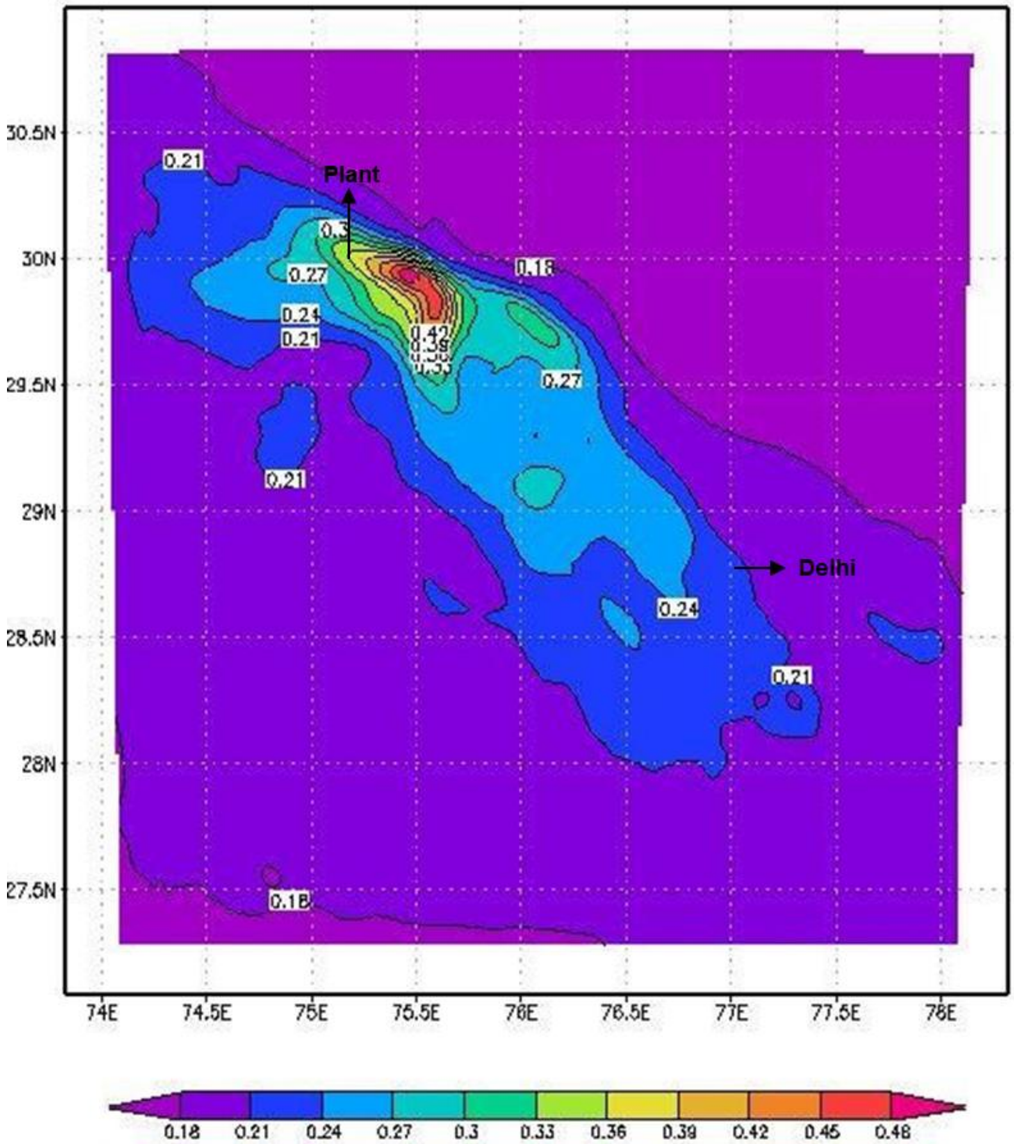


Figure 68: Monthly Mean SO_4 Concentration($\mu g/m^3$)

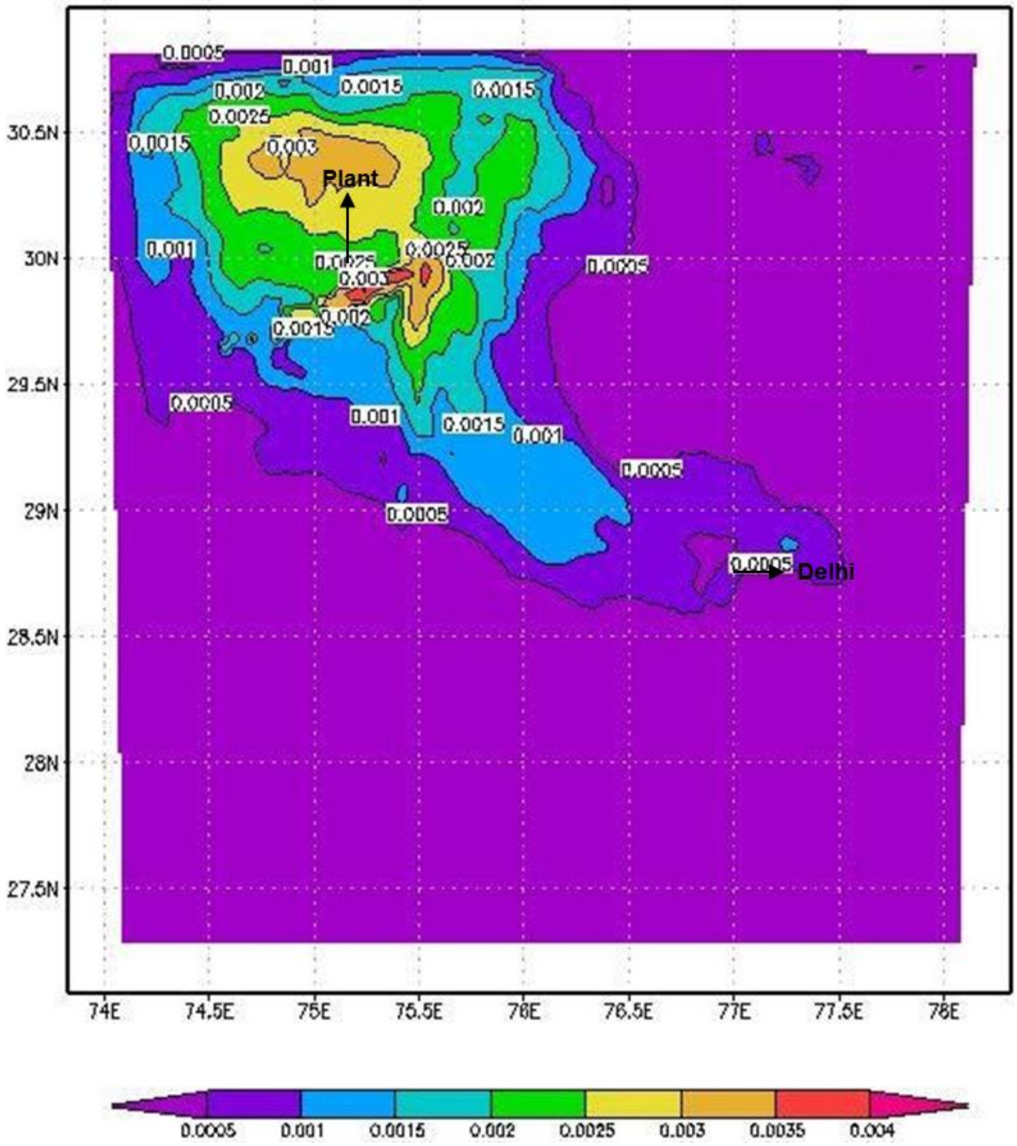


Figure 69: Monthly Mean NO_3 Concentration($\mu g/m^3$); use a multiplying factor of 16 for corrected concentrations

13. Conclusions

Although in the FY 2018-19, the plant load factor is 61.34%, however, to obtain maximum impact, which may occur during full load operation, all modelling results pertain to full load of the plant. The conclusions are as following.

1. The yearly wind rose analysis shows the prominent wind direction of the North-west.
2. The model-computed SO_2 peak concentration is in the month of April 45.9 µg/m^3. It may be noted that the peak contribution towards S-E direction (towards Delhi) was 40 µg/m^3 (in April) at a distance of about 2.0 km and drops sharply to less than 1 µg/m^3 at a distance of 40 km from the plant. Thus, beyond 40 km the impact of SO_2 becomes insignificant.
3. The peak concentration of SO_2 in other months (December and January) ranges from 25.5 to 29.8 µg/m^3 at about 3.0 km. The peak concentration beyond 40 km drops to less than 5 µg/m^3 in December and January towards S-E direction.
4. The NO_2 modelled-peak concentration was in April at 52 µg/m^3. It may be noted that the peak contribution towards S-E direction was 45 µg/m^3 at a distance of 2.5 km and drops sharply to less than 1 µg/m^3 at a 40 km distance from the plant. Thus, beyond 40 km the impact of NO_2 becomes insignificant.

5. The peak concentration of NO_2 in the month of December and January was 29 – 34 µg/m^3 at a distance of 2-3 km. The peak concentration beyond 40 km drops to less than 5 µg/m^3 in December and January towards S-E direction

6. It may be concluded that the peak concentration of SO_2 and NO_2 lies within 5 km and dropped quickly after that and the impact beyond 40 km is insignificant.

7. Sulfate levels increase as one moves away from the plant site in the S-E direction, and up to a distance of about 100 km, the peak weekly concentration is in the range of 0.40 - 0.90 µg/m^3. However, at a distance of about 250 km (in S-E) the levels are dropped by nearly 60% to 0.18 – 0.30 µg/m^3. It may be noted that S-E is the prevailing downwind direction from the plant and sulfate impact is seen for a long distance.

8. Weekly nitrate levels have shown increased levels in S-E direction (0.06- 0.10 $\mu g/m^3$) at about 50-55 km compared to the levels very close to the plant site. However, at a distance of about 250 km (in S-E), the levels are at 0.01 $\mu g/m^3$.

9. The mean monthly peak concentration of sulfate, 0.48 $\mu g/m^3$ (somewhat lower than peak weekly concentration) was estimated in the S-E direction at about 40 km. Nitrate levels show monthly peak concentration is 0.06 $\mu g/m^3$ towards S-E to as low as 0.01 $\mu g/m^3$ in the S-E.

10. The 24-hourly mean peak concentration of SO_4 was 2.18 $\mu g/m^3$ in the S-E direction at 12 km which drops to 0.73 $\mu g/m^3$ in S-E direction at a distance of about 250 km (Table 1). The 24-hourly mean peak concentration of NO_3 was 0.41 $\mu g/m^3$ in S-E direction at a distance of about 12 km and it drops to less than 0.002 $\mu g/m^3$ at a distance of about 250 km.

In summary, the peak contribution of SO_2 and NO_2 is insignificant beyond 40 km from the plant. It may be noted that for higher averaging time (e.g. 24-hr, monthly) the levels will reduce quite rapidly and become insignificant beyond 10 km from the plant.

The impact of sulfate, although relatively small (the peak weekly concentration: 0.40 - 0.90 $\mu g/m^3$), it extends well beyond 50 km and up to 250 km with smaller concentrations in the range 0.18- 0.30 $\mu g/m^3$.

The impact of nitrate (the peak weekly concentration: 0.06- 0.10 $\mu g/m^3$) at about 50 km. However, the impact extends well beyond 50 km and up to 250 km with smaller concentrations of 0.01 $\mu g/m^3$.

The peak air quality Index (AQI) in Delhi was about 500 during November 2018 which corresponds to 380 $\mu g/m^3$ of $PM_{2.5}$. Considering that 24-hr sulfate concentration contributed by plant at a distance of about 250 km(i.e. near Delhi) is 0.73 $\mu g/m^3$, that is about 0.2%.

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