MODELING OF DISPERSION OF NITROGEN OXIDE (NOx) FROM Dr. NARLATATA RAO THERMAL POWER PLANT USING AERMOD MODEL

K.Pravallika

Asst Executive Engineer

Sri Venkateshwara University college of engineering,

Dr.N.Munilakshmi

Associate professor

Sri Venkateshwara University College.

1. INTRODUTION:

An air pollutant is known as a substance in the air that can cause harm to humans and the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases. Power plants are the major sources of air pollution. Coal is the primary fuel used for generation of electricity in India and its usage is continually increasing to meet the growing energy demands of the country. Emissions of greenhouse gases and other pollutants such as Nitrogen Oxide (NO_x) are increasing parallel to the growing demands of electricity. Implications of power plant emissions on the environment depend on the concentration of NO_x pollutant emitted and in the recent past they are at alarming levels. Therefore, it is necessary to predict the concentration of NO_x pollutant for impact assessment.

The study was carried out in two levels. In Level 1 study, impact assessment was made by screening level dispersion modeling technique using worst case input data employing Gaussian formulae. Level 2 studies included an assessment by a refined dispersion modeling technique (AERMOD) using site-specific input data. Level 1 impact assessment would be more conservative and less specific than the result of Level 2 assessments. It is not intended that an assessment should routinely progress through the two levels. If the air quality impact is considered to be a significant issue from Level 1 assessment, there is a need to immediately conduct of Level 2 assessments.

2. OBJECTIVES:

Dr. Narla Tata Rao Thermal Power Plant (NTTP), Ibrahimpatnam, Vijayawada, Andhra Pradesh, is selected as a case-study in the present investigation for the assessment of air quality of the region.

The following are the objectives of the present study:

- To develop an emission inventory for the study area
- To evolve wind roses of the study area
- To predict concentration of primary pollutant namely Nitrogen Oxide (NO_x) using Gaussian formulae
- To assess ground level concentration of primary pollutant Nitrogen Oxide (NO_x) by using AERMOD (America Meteorological Environmental Protection Agency Regulatory Model)
- To evolve the Isopleths of the study area in AERMOD

3. STUDY AREA:

The Dr. Narla Tata Rao Thermal Power Plant (NTTP) Vijayawada, of capacity 2x 210 MW and 1x 500 MW of total 1760 MW is coal-fired based one. This thermal power station is predominantly government assigned land covering total area of 397.7Acres (167.7 Acres Existing Land & 230 Acres to be acquired).The proposed power plant location falls between **16$_0$35'27''N** Latitude and **80$_0$32'00''E** Longitude.

4. METHODOLOGY:

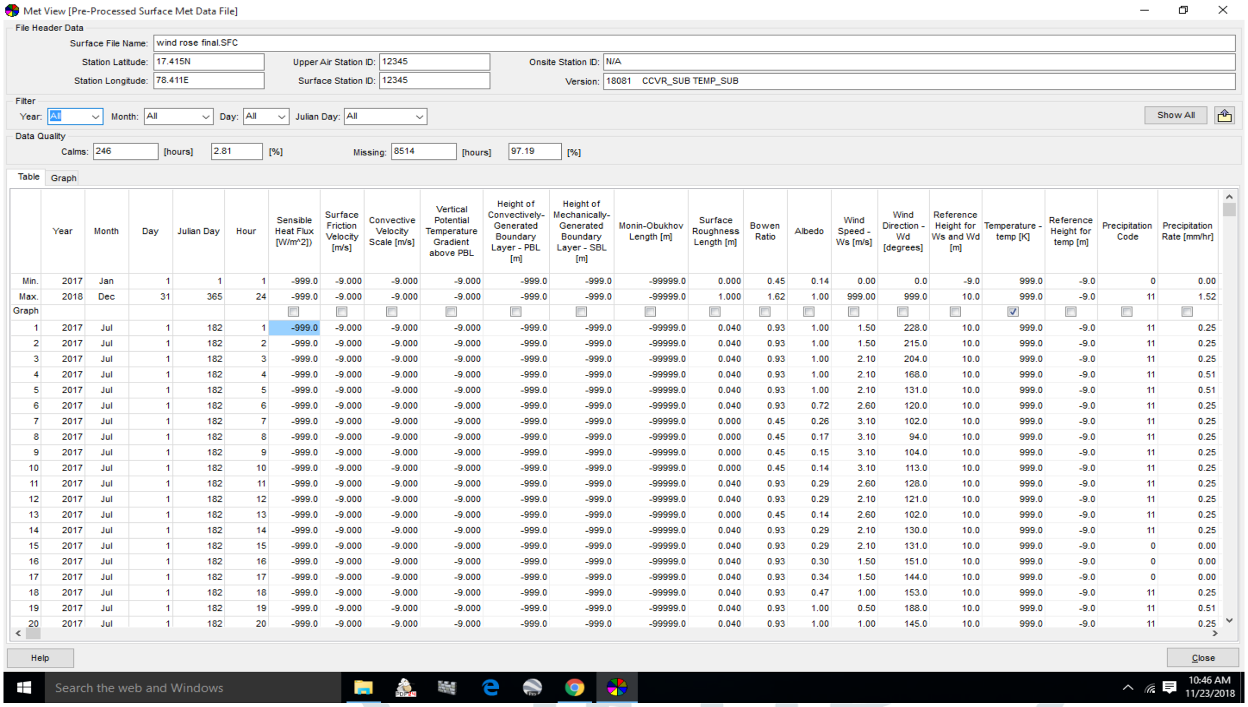
This chapter includes the following:

- Levels of Assessment
- Emissions inventory for the present case study
- Input of meteorological data
- Evolution of wind roses
- Prediction of primary pollutants by using Gaussian formulae
- AERMOD dispersion modeling methodology, Interpretation of dispersion Modeling results for NO_x

5. RESULTS AND DISCUSSIONS:

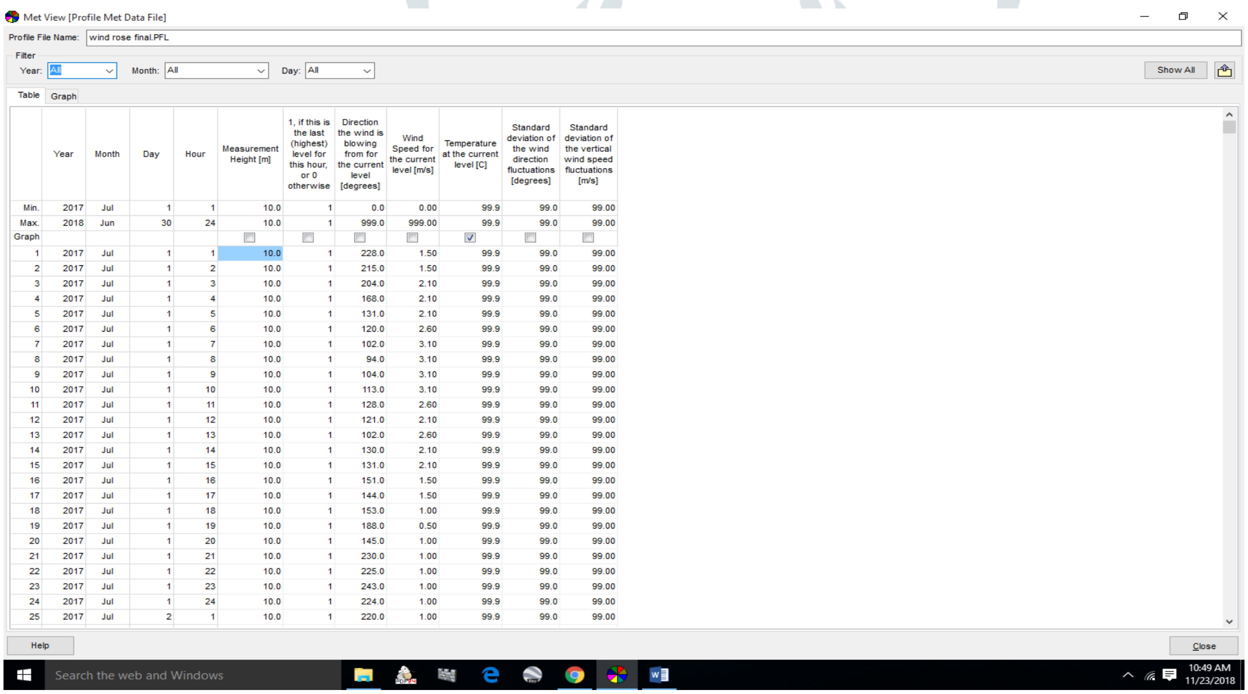
The AERMOD model used in this study requires input information for an emission sources at the Dr.Narla Tata Rao Thermal Power Plant site-specific meteorological data of one complete year. The input data that describe both the emission source and meteorology provide a comprehensive set of information which can be used to run the AERMOD model and thus simulate the ground level concentration of Nitrogen Oxide (NO_x) from stationary sources of a thermal power plant.

In addition the model requires the site-specific meteorological information as input data. The local meteorological information that was to be given as input into the model were restricted to the Julian day of the year, the average wind flow vector, wind speed, height of the mixing layer, ambient Air temperature and the Pasquill stability category. The data were collected from Indian Meteorological Department, from web available by satellite data and from the website www.metcheck.com/IN/.



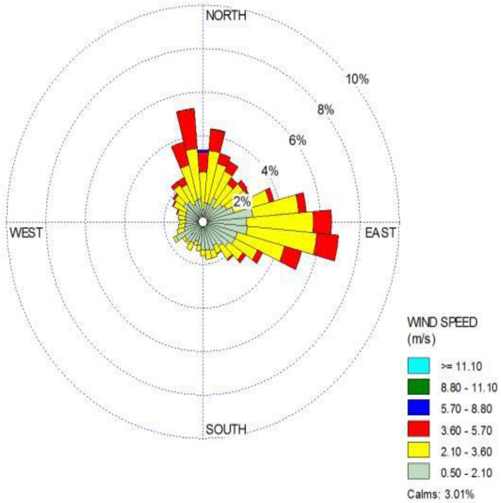
	Year	Month	Day	Julian Day	Hour	Sensible Heat Flux [W/m^2])	Surface Friction Velocity [m/s]	Convective Velocity Scale [m/s]	Vertical Potential Temperature Gradient above PBL	Height of Convectively-Generated Boundary Layer - PBL [m]	Height of Mechanically-Generated Boundary Layer - SBL [m]	Monin-Obukhov Length [m]	Surface Roughness Length [m]	Bowen Ratio	Albedo	Wind Speed - Ws [m/s]	Wind Direction - Wd [degrees]	Reference Height for Ws and Wd [m]	Temperature - temp [K]	Reference Height for temp [m]	Precipitation Code	Precipitation Rate [mm/hr]
Min.	2017	Jan	1	1	1	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.000	0.45	0.14	0.00	0.0	-9.0	999.0	-9.0	0	0.00
Max.	2018	Dec	31	365	24	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	1.000	1.62	1.00	999.00	999.0	10.0	999.0	-9.0	11	1.52
Graph						☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐
1	2017	Jul	1	182	1	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	1.00	1.50	228.0	10.0	999.0	-9.0	11	0.25
2	2017	Jul	1	182	2	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	1.00	1.50	215.0	10.0	999.0	-9.0	11	0.25
3	2017	Jul	1	182	3	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	1.00	2.10	204.0	10.0	999.0	-9.0	11	0.25
4	2017	Jul	1	182	4	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	1.00	2.10	168.0	10.0	999.0	-9.0	11	0.51
5	2017	Jul	1	182	5	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	1.00	2.10	131.0	10.0	999.0	-9.0	11	0.51
6	2017	Jul	1	182	6	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	0.72	2.60	120.0	10.0	999.0	-9.0	11	0.25
7	2017	Jul	1	182	7	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.000	0.45	0.26	3.10	102.0	10.0	999.0	-9.0	11	0.25
8	2017	Jul	1	182	8	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.000	0.45	0.17	3.10	94.0	10.0	999.0	-9.0	11	0.25
9	2017	Jul	1	182	9	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.000	0.45	0.15	3.10	104.0	10.0	999.0	-9.0	11	0.25
10	2017	Jul	1	182	10	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.000	0.45	0.14	3.10	113.0	10.0	999.0	-9.0	11	0.25
11	2017	Jul	1	182	11	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	0.29	2.60	128.0	10.0	999.0	-9.0	11	0.25
12	2017	Jul	1	182	12	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	0.29	2.10	121.0	10.0	999.0	-9.0	11	0.25
13	2017	Jul	1	182	13	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.000	0.45	0.14	2.60	102.0	10.0	999.0	-9.0	11	0.25
14	2017	Jul	1	182	14	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	0.29	2.10	130.0	10.0	999.0	-9.0	11	0.25
15	2017	Jul	1	182	15	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	0.29	2.10	131.0	10.0	999.0	-9.0	0	0.00
16	2017	Jul	1	182	16	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	0.30	1.50	151.0	10.0	999.0	-9.0	0	0.00
17	2017	Jul	1	182	17	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	0.34	1.50	144.0	10.0	999.0	-9.0	0	0.00
18	2017	Jul	1	182	18	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	0.47	1.00	153.0	10.0	999.0	-9.0	11	0.25
19	2017	Jul	1	182	19	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	1.00	0.50	188.0	10.0	999.0	-9.0	11	0.51
20	2017	Jul	1	182	20	-999.0	-9.000	-9.000	-9.000	-999.0	-999.0	-99999.0	0.040	0.93	1.00	1.00	145.0	10.0	999.0	-9.0	11	0.25

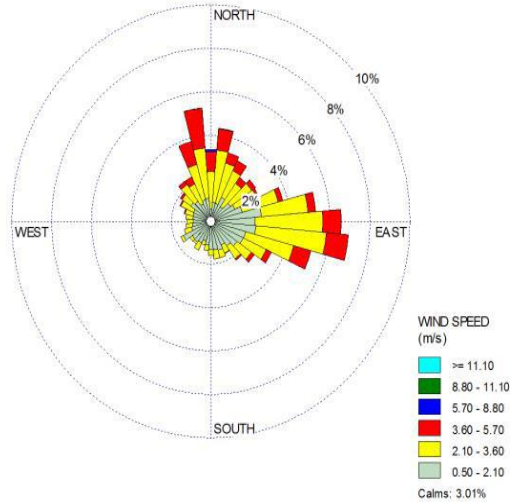
Meteorological data output surface file for AERMOD



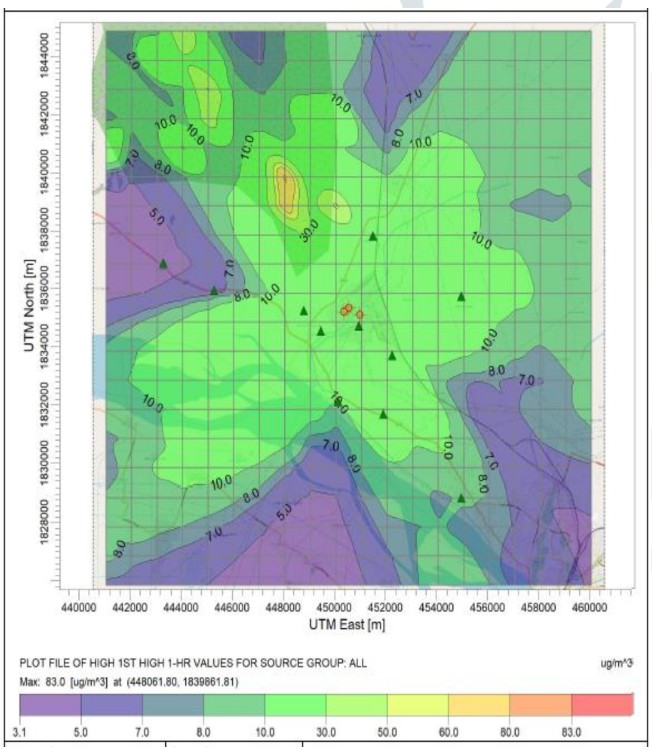
	Year	Month	Day	Hour	Measurement Height [m]	1, if this is the last (highest) level for this hour, or 0 otherwise	Direction the wind is blowing from for the current level [degrees]	Wind Speed for the current level [m/s]	Temperature at the current level [C]	Standard deviation of the wind direction fluctuations [degrees]	Standard deviation of the vertical wind speed fluctuations [m/s]
Min.	2017	Jul	1	1	10.0	1	0.0	0.00	99.9	99.0	99.00
Max.	2018	Jun	30	24	10.0	1	999.0	999.00	99.9	99.0	99.00
Graph					☐	☐	☐	☐	☑	☐	☐
1	2017	Jul	1	1	10.0	1	228.0	1.50	99.9	99.0	99.00
2	2017	Jul	1	2	10.0	1	215.0	1.50	99.9	99.0	99.00
3	2017	Jul	1	3	10.0	1	204.0	2.10	99.9	99.0	99.00
4	2017	Jul	1	4	10.0	1	168.0	2.10	99.9	99.0	99.00
5	2017	Jul	1	5	10.0	1	131.0	2.10	99.9	99.0	99.00
6	2017	Jul	1	6	10.0	1	120.0	2.60	99.9	99.0	99.00
7	2017	Jul	1	7	10.0	1	102.0	3.10	99.9	99.0	99.00
8	2017	Jul	1	8	10.0	1	94.0	3.10	99.9	99.0	99.00
9	2017	Jul	1	9	10.0	1	104.0	3.10	99.9	99.0	99.00
10	2017	Jul	1	10	10.0	1	113.0	3.10	99.9	99.0	99.00
11	2017	Jul	1	11	10.0	1	128.0	2.60	99.9	99.0	99.00
12	2017	Jul	1	12	10.0	1	121.0	2.10	99.9	99.0	99.00
13	2017	Jul	1	13	10.0	1	102.0	2.60	99.9	99.0	99.00
14	2017	Jul	1	14	10.0	1	130.0	2.10	99.9	99.0	99.00
15	2017	Jul	1	15	10.0	1	131.0	2.10	99.9	99.0	99.00
16	2017	Jul	1	16	10.0	1	151.0	1.50	99.9	99.0	99.00
17	2017	Jul	1	17	10.0	1	144.0	1.50	99.9	99.0	99.00
18	2017	Jul	1	18	10.0	1	153.0	1.00	99.9	99.0	99.00
19	2017	Jul	1	19	10.0	1	188.0	0.50	99.9	99.0	99.00
20	2017	Jul	1	20	10.0	1	145.0	1.00	99.9	99.0	99.00
21	2017	Jul	1	21	10.0	1	230.0	1.00	99.9	99.0	99.00
22	2017	Jul	1	22	10.0	1	225.0	1.00	99.9	99.0	99.00
23	2017	Jul	1	23	10.0	1	243.0	1.00	99.9	99.0	99.00
24	2017	Jul	1	24	10.0	1	224.0	1.00	99.9	99.0	99.00
25	2017	Jul	2	1	10.0	1	220.0	1.00	99.9	99.0	99.00

Meteorological data output profile file for AERMOD

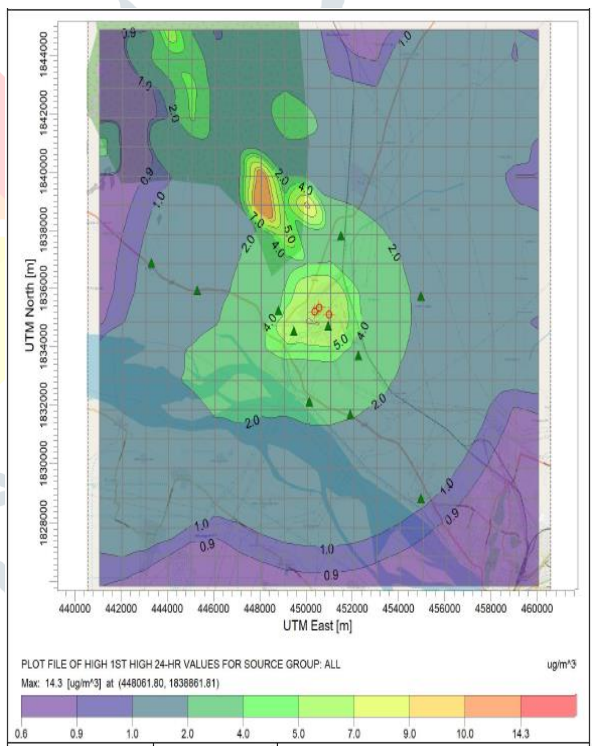




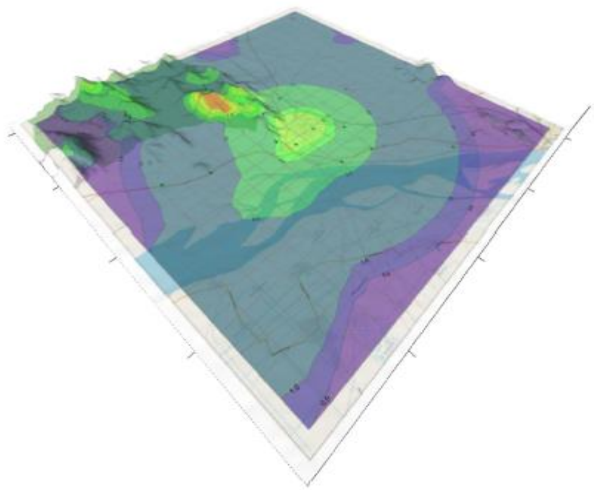
Surface file wind rose **Profile file wind rose**

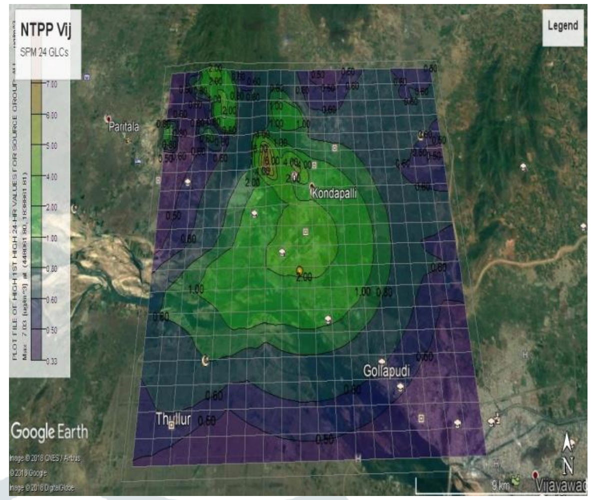


Isopleths for 1hr NOx concentration



Isopleths for 24hr NOx concentration





Isopleths for 3D NOx concentration **Spatial Distribution of NOx over Study Area**

VALIDATION OF AERMOD:

Details of Source and Monitoring Station in the Study Area

Source/ Monitoring Station	Location	Latitude	Longitude
Source Points	Stack 1	16.5887^{0}N	80.5542^{0}E
	Stack 2	16.5907^{0}N	80.5632^{0}E
	Stack 3	16.5967^{0}N	80.5232^{0}E
Monitoring Stations	AAQMS 1	16.58707^{0}N	80.5332^{0}E
	AAQMS 2	16.5927^{0}N	80.5632^{0}E
	AAQMS 3	16.5807^{0}N	80.6332^{0}E

The Predicted values of criteria pollutants NOx from output files of AERMOD with background concentrations are as shown in table.

Predicted Values of NO_x Pollutant from Output Files of AERMOD

MONTHS	Pollutant Concentration (µg/m^3) Background Concentration is 23 (µg/m^3) NO_x
July 2017	38.80
August 2017	36.30
September 2017	33.28
October 2017	28.69
November 2017	28.75
December2017	32.74
January 2018	37.10
February 2018	38.80
March 2018	39.00
April 2018	41.20
May 2018	46.10
June 2018	47.60

The Predicted and Measured concentrations of Nitrogen Oxide (NO_x) are as shown in table.

Predicted and Measured Concentrations of NO_x

MONTHS	AAQMS 1 (Projectsite)		AAQMS 2 (Ibrahimpatnam)		AAQMS 3 (Hill point)	
	P (µg/m^3)	M (µg/m^3)	P (µg/m^3)	M (µg/m^3)	P (µg/m^3)	M (µg/m^3)
July 2017	38.80	35.42	38.80	34.6	38.80	37.6

August 2017	36.30	36.26	36.30	36.32	36.30	33.5
September 2017	33.28	33.25	33.28	30.5	33.28	32.4
October 2017	28.69	25.42	28.69	26.9	28.69	28.6
November 2017	28.75	28.52	28.75	24.32	28.75	26.4
December 2017	32.74	32.85	32.74	28.45	32.74	31.4
January 2018	37.10	32.6	37.10	38.5	37.10	33.8
February 2018	38.80	33.45	38.80	39.5	38.80	31.5
March 2018	39.00	40.36	39.00	38.4	39.00	36.8
April 2018	41.20	35.56	41.20	38.6	41.20	46.3
May 2018	46.10	38.36	46.10	49.8	46.10	44.5
June 2018	47.60	47.84	47.60	46.4	47.60	45.5

Statistical Performance Measures of AERMOD Model:

Parameter	**Monitoring station**	**R^2**	**Inference**
NO_X	AAQMS 1	0.90	Strong positive correlation
	AAQMS 2	0.92	Strong positive correlation
	AAQMS 3	0.78	Moderate positive correlation

6. CONCLUSION REMARKS:

From level 1 assessment, it was noticed that NOx concentration were high and exceeding National Ambient Air Quality Standards, prescribed by the Central Pollution Control Board. In Level – 2 assessments, replication of pollutant NOx dispersion from Dr.Narla Tata Rao Thermal Power Plant was obtained by applying an AERMOD model and the results of predicted values were compared with the measured concentrations at the NTTP site from July 2017 to June 2018 made available by APPCB.

Nitrogen Oxides (NOx) varies from 28.69µg/m3to 38.80µg/m3 from the month of July 2017 to June 2018 using AERMOD model. Value of R^2 at AAQMS 1 project site is 0.90 which is strong positive correlation, AAQMS 2 ibrahimpatanam is 0.92 which is strong positive correlation and AAQMS 3 hill station is 0.78 which is moderate positive correlation.

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