Role of thermal power plants in particulate matter emission # A case study of NTPC Dadri plant – Using DMAIC approach

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Abstract:

India is going to ratify Paris agreement this year which will give a target to reduce its emission by 55%. Thermal power plants contribute a major role in polluting environment. Around 58% of CO_2 emission is carried by thermal units only. Since the genesis of NTPC It has led in environment concern from the front. NTPC Dadri is a unique power plant of NTPC group which has coal based thermal plant and gas based thermal plant of 1820 MW and 817 MW respectively and 5 MW solar plant . At NTPC Dadri plant ambient air quality is measured at three distinct point and various parameters like Sox, NOx, CO2 , PM10, PM2.5, wind speed, Relative humidity, Solar radiation, O_3 , rain are measured on real time basis. In present paper DMAIC study has been done to find out the emission trends in Dadri plant. Using Minitab 17.0 software.The purpose of DMAIC study helps in analysis and also provides us how much minimum emission figure can we achieve statistically? Process capability curve of PM2.5 and PM10 are measured. Six month data has been taken for analysis and it is found NTPC Dadri is maintaining emission norms defined by MoEF but in PM10 emission it has scope for improvements. PM2.5 emissions has high 3.45 sigma level of conformance while PM10 is running under 1 sigma level of conformance. Various approaches adopted by Dadri management has also been discussed and a study of retro fitment in ESP is also discussed briefly. NTPC stands on renewable sources of energy especially solar energy is helping in cutting carbon emissions. NTPC has to go for power bundling in old plants (where PPAs are complete or about to complete) and promising in increasing RGO (renewable generation obligation) target as specified recently by ministry of power.

Keywords: PM10, PM2.5, Minitab, DMAIC , RGO

INTRODUCTION

Air pollution has become one of the biggest environmental health risks ever. Millions of people die each year due to ailments where the cause of death has been linked to constant exposure to polluted air. Of the 6-7 million premature deaths each year due to air pollution, more than 50% of those occur in China and India alone. As per a recent study **air pollution is the fifth largest cause of deaths in India**.

Recently environment ministry has launched **National Air Quality Index (AQI).** AQI has proposed '**One Number- One Color-One Description'** to judge the Air Quality for Common Man. This is a comprehensive approach to find out measure pollutants. . Under the current measurement of air quality, 8 parameters are being measured. These are PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Pb for which short-term (up to 24-hourly averaging period) National Ambient Air Quality Standards are prescribed. AQI is a good index to monitor air quality and tells how clean or unhealthy the air is and associated health effects. To monitor pollution CPCB is executing a nation-wide programme of ambient air quality monitoring known as National Air Quality Monitoring Programme (NAMP). Under N.A.M.P., four air pollutants *viz* ., Sulphur Dioxide (SO2), Oxides of Nitrogen as NO2, Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM / PM10) have been identified for regular monitoring at all the locations. The monitoring of meteorological parameters such as wind speed and wind direction, relative humidity (RH) and temperature were also integrated with the monitoring of air quality.

WHAT IS PARTICULATES MATTER?

Particulate matter (PM) or particulates are microscopic solid or liquid matter suspended in the Earth's atmosphere. Some particles are large enough to be seen, and others are so small they can only be detected with an electron microscope Solid and liquid matter of organic or inorganic composition, suspended in flue gas or in the atmosphere is generally referred to as particulate. Particle size from combustion sources are usually found between 1 to 100 microns, although particles smaller than 1 micron can occur through condensation processes. These fine particles are formed in the atmosphere

when gases such as SO2, NOx, and volatile organic compounds (VOCs), emitted by combustion processes, are transformed into fine particulate by chemical reactions in the air (i.e., sulfuric acid, nitric acid and photochemical smog). There are broadly two types of PM – a. PM10 - Coarse dust particles (PM10) are 2.5 to 10 micrometers in diameter. PM10 include dust produced during crushing or grinding operations and dust stirred up by vehicles on roads. b. PM2.5 - Fine particles (PM2.5) are 2.5 micrometers or less in diameter and can only be seen with an electron microscope. Fine particles are produced from all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes. PM2.5 is considered to have more detrimental health effects than the coarser particles. Among the effects of particulate emissions are impaired visibility such as smog and haze, soiling of surrounding areas, aggravation of the adverse effects of SO2, impaired plant growth and human respiratory problems. Sources of particulate matter can be man-made or natural. They have impacts on climate and precipitation that adversely affect human health. Particles come in a wide range of sizes. Particles less than or equal to 10 micrometers in diameter are so small that they can get into the lungs, potentially causing serious health problems.

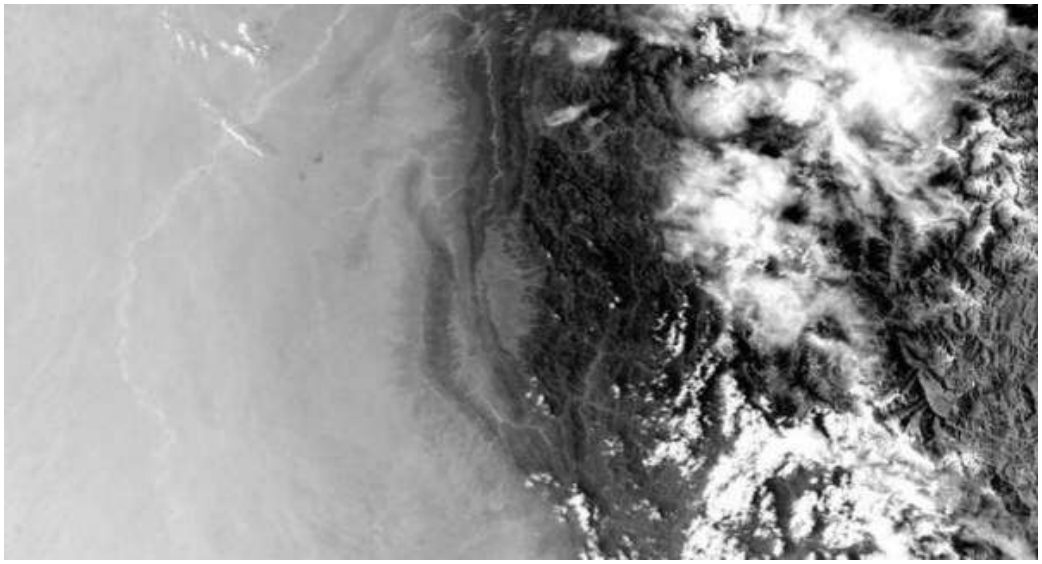


Fig. Picture of polluted India from space taken by US astronaut Scott Kelly (Left part : India , right Part : Himalaya The haziness over India depicts level of pollution with respect to Nepal and Himalaya region)

According to a database of PM 2.5 pollution produced by the WHO in 2014, 13 of the world's 20 most polluted cities are in India. Delhi, Patna, Gwalior and Raipur are the top four in the list. Apart from health hazard PM also affect us by Reducing visibility (haziness) , Stain and damage buildings and statues ,Increase acidity in water bodies or change the flow of nutrients and Deplete the soil and damage forests and crops .Burning Coal in a power plant produces a number of pollutants. Some of these pollutants are specific to the type of fuel or is part of the combustion process or related to the design and configuration of the plant. The major pollutants discharged from the power plant are: Carbon Dioxide (CO2) , Sulphur Dioxide (SO2) , Ash, Particulate Matter and Nitrogen Oxides (NOx) .

CASE- STUDY OF NTPC DADRI PLANT:

In NTPC dadri plant ambient air quality is measured at three distinct point and various paramteters like Sox, NOx, CO_2 , PM10, PM2.5, wind speed, Relative humidity, Solar radiation, O_3 , rain are measured on real time basis. Following is picture of NTPC Dadri intranet in which these parameters come in AAQMS data.

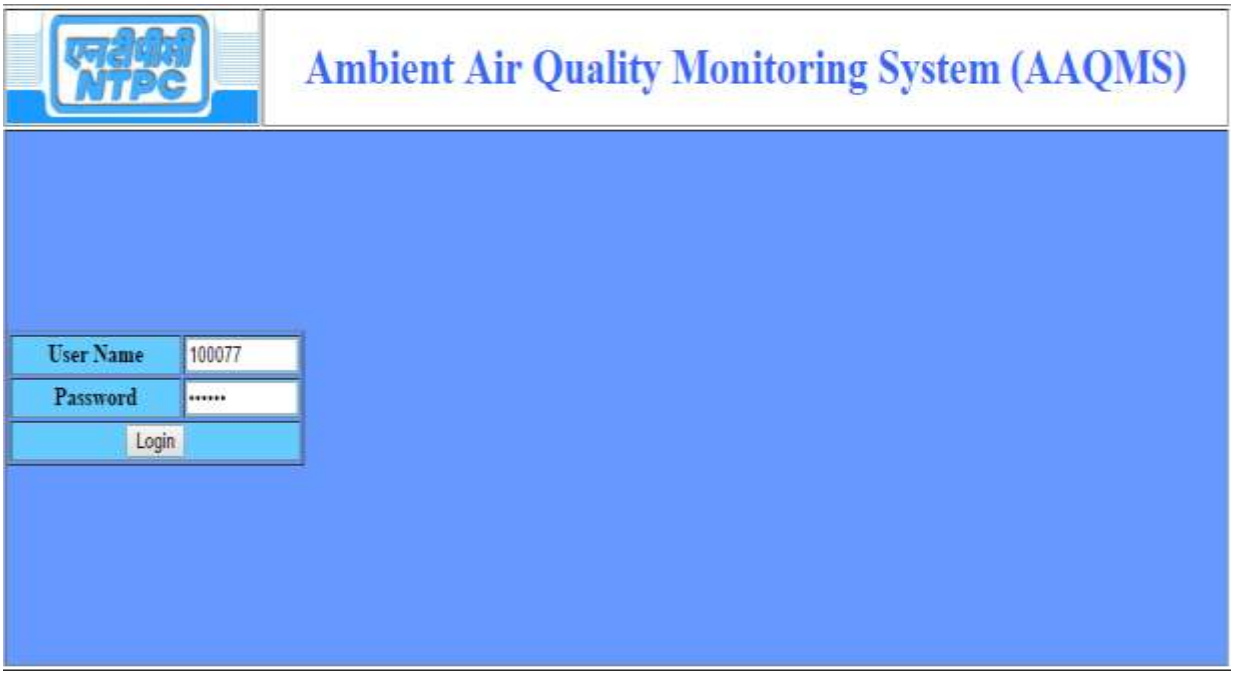
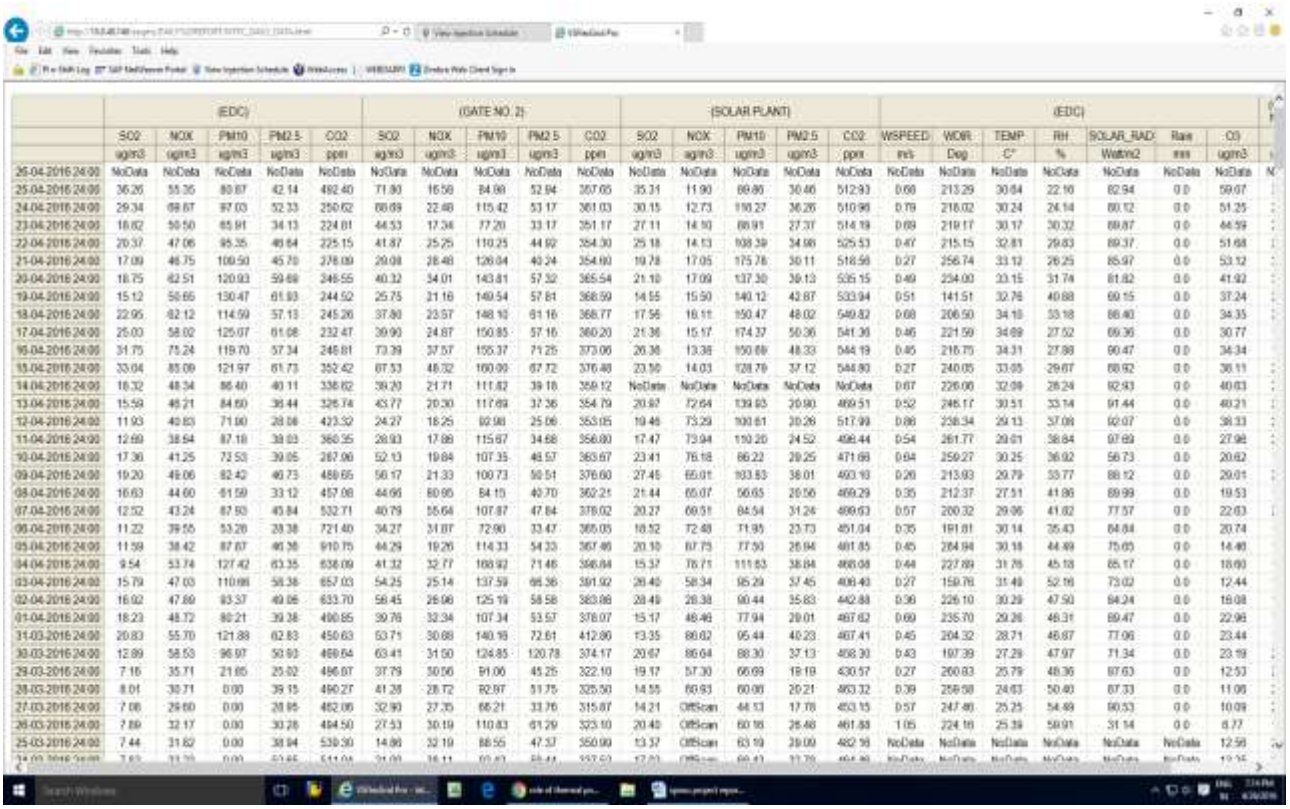


Fig. Intranet of NTPC dadri showing link for AAQMS

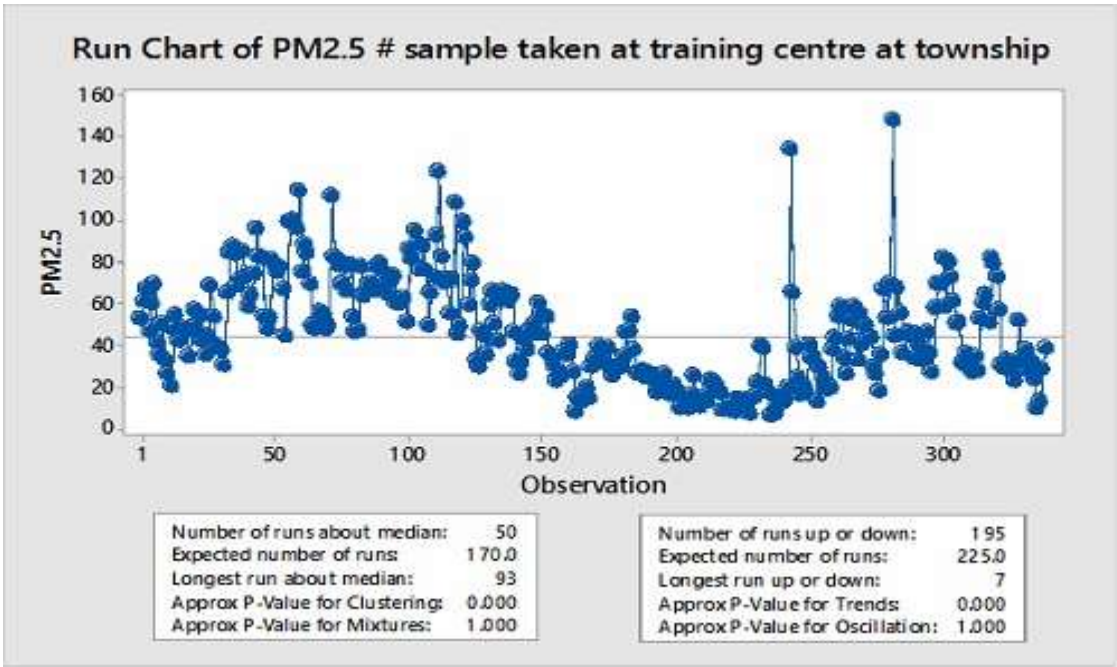
Following is a snapshot of Run-time data

Following is data (6 months) :

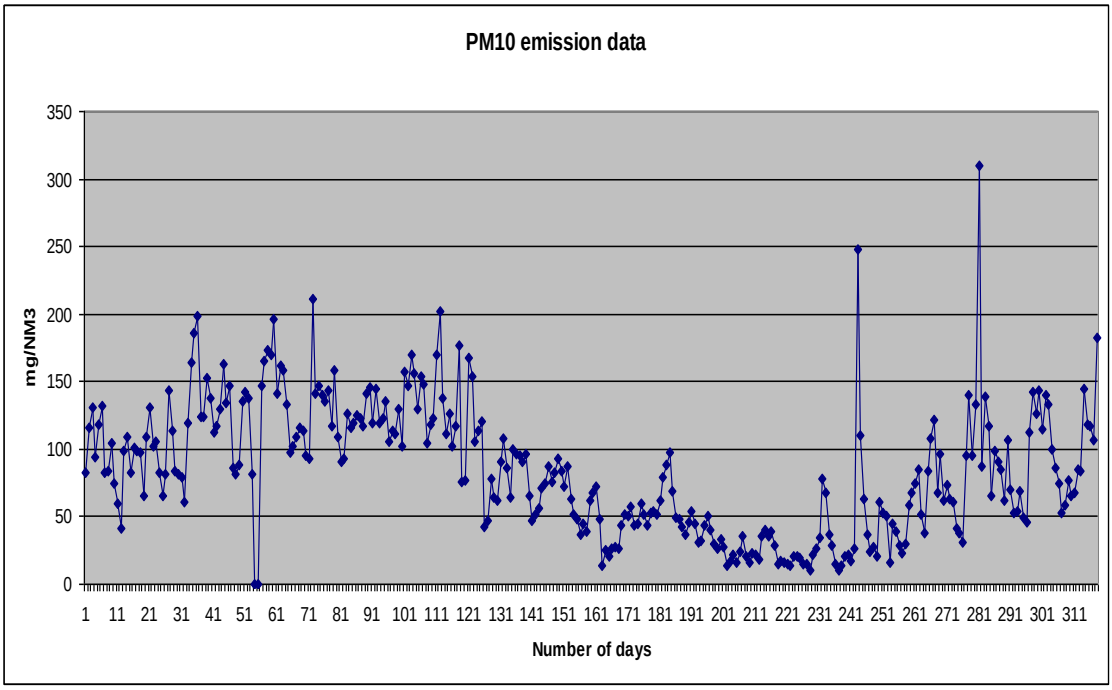


	(EDC)					(GATE NO. 2)					(SOLAR PLANT)					(EDC)						
	SO2	NOX	PM10	PM2.5	CO2	SO2	NOX	PM10	PM2.5	CO2	SO2	NOX	PM10	PM2.5	CO2	WSPEED	WDIR	TEMP	RH	SOLAR_RAD	Rain	CO
	ug/m3	ug/m3	ug/m3	ug/m3	ppm	ug/m3	ug/m3	ug/m3	ug/m3	ppm	ug/m3	ug/m3	ug/m3	ug/m3	ppm	m/s	Deg	C°	%	Watts/m2	mm	ug/m3
26-04-2016 24:00	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData	NoData
25-04-2016 24:00	36.26	55.35	80.87	42.14	492.40	71.80	16.58	84.88	52.84	357.05	35.31	11.90	69.86	30.46	512.93	0.68	213.29	30.64	22.16	82.94	0.0	59.07
24-04-2016 24:00	29.34	68.87	97.03	52.33	250.62	68.69	22.48	115.42	53.17	361.03	30.15	12.73	110.27	36.26	510.96	0.79	218.02	30.24	24.14	80.12	0.0	51.25
23-04-2016 24:00	16.62	50.50	65.91	34.13	224.81	44.53	17.36	77.20	33.17	351.17	27.11	14.10	88.91	27.37	514.19	0.69	219.17	30.17	30.32	69.87	0.0	44.59
22-04-2016 24:00	20.37	47.06	95.35	49.64	225.15	41.87	25.25	110.25	44.92	364.30	25.18	14.13	108.39	34.98	525.53	0.47	215.15	32.81	29.83	89.37	0.0	51.68
21-04-2016 24:00	17.09	46.75	109.50	45.70	278.09	29.08	28.48	126.04	40.24	354.60	19.78	17.05	175.78	30.11	518.56	0.27	256.74	33.12	26.25	85.97	0.0	53.12
20-04-2016 24:00	18.75	62.51	120.93	59.69	248.55	40.32	34.01	143.81	57.32	365.54	21.10	17.09	137.30	39.13	535.15	0.49	234.00	33.15	31.74	81.82	0.0	41.92
19-04-2016 24:00	15.12	50.65	130.47	61.93	244.52	25.75	21.16	149.54	57.81	368.59	14.55	15.50	140.12	42.87	533.94	0.51	141.51	32.76	40.88	69.15	0.0	37.24
18-04-2016 24:00	22.95	62.12	114.59	57.13	245.26	37.80	23.57	148.10	61.16	368.77	17.56	16.11	150.47	48.02	549.82	0.68	206.50	34.10	33.18	88.40	0.0	34.35
17-04-2016 24:00	25.03	58.02	125.07	61.08	232.47	39.90	24.87	150.85	57.16	360.20	21.36	15.17	174.37	50.36	541.36	0.46	221.59	34.69	27.52	69.36	0.0	30.77
16-04-2016 24:00	31.75	75.24	119.70	57.34	246.81	73.39	37.57	155.37	71.25	373.06	26.36	13.38	150.69	48.33	544.19	0.45	215.75	34.31	27.88	69.47	0.0	34.34
15-04-2016 24:00	33.04	85.09	121.97	61.73	352.42	67.53	48.32	160.09	67.72	376.48	23.50	14.03	128.79	37.12	544.80	0.27	240.05	33.05	29.67	88.92	0.0	36.11
14-04-2016 24:00	16.32	48.34	86.40	40.11	336.02	39.20	21.71	111.82	39.16	359.12	NoData	NoData	NoData	NoData	NoData	0.67	226.06	32.09	28.24	82.93	0.0	40.63
13-04-2016 24:00	15.59	46.21	84.60	36.44	326.74	43.77	20.30	117.69	37.36	354.79	20.97	12.64	139.65	20.90	469.51	0.52	246.17	30.51	33.14	91.44	0.0	40.21
12-04-2016 24:00	11.93	40.83	71.00	28.08	423.32	24.27	18.25	92.98	25.06	353.05	19.48	13.29	100.61	20.26	517.99	0.86	238.34	29.13	37.09	92.07	0.0	38.33
11-04-2016 24:00	12.69	38.64	87.18	39.03	360.35	28.93	17.89	115.67	34.68	356.80	17.47	13.94	110.20	24.52	496.44	0.54	261.77	29.61	36.84	97.69	0.0	27.98
10-04-2016 24:00	17.36	41.25	72.53	39.05	267.06	52.13	19.84	107.35	46.57	365.67	23.41	16.18	86.22	29.25	471.66	0.64	259.27	30.25	36.92	96.73	0.0	20.62
09-04-2016 24:00	19.20	49.06	82.42	46.73	489.65	56.17	21.33	100.73	50.51	376.60	27.45	65.01	103.83	38.01	493.10	0.26	213.93	29.79	33.77	88.12	0.0	29.01
08-04-2016 24:00	16.63	44.60	61.59	33.12	457.06	44.66	80.66	84.15	40.70	362.21	21.44	65.07	56.65	29.56	469.29	0.35	212.37	27.51	41.86	89.99	0.0	19.53
07-04-2016 24:00	12.52	43.24	67.93	45.84	532.71	40.79	55.64	107.87	47.84	378.02	20.27	69.51	84.54	31.24	499.63	0.57	200.32	29.96	41.82	77.57	0.0	22.63
06-04-2016 24:00	11.22	39.55	53.28	28.38	721.40	34.27	31.87	72.90	33.47	365.05	18.52	72.48	71.95	23.73	451.04	0.35	191.81	30.14	35.43	84.84	0.0	20.74
05-04-2016 24:00	11.59	38.42	87.67	46.26	910.75	44.29	19.26	114.33	54.33	367.46	20.10	67.75	77.50	26.84	491.85	0.45	264.94	30.18	44.49	75.65	0.0	14.46
04-04-2016 24:00	9.54	53.74	127.42	63.35	638.09	41.32	32.77	188.92	71.46	398.84	15.37	78.71	111.63	38.84	488.68	0.44	227.89	31.76	45.18	85.17	0.0	18.60
03-04-2016 24:00	15.79	47.03	110.66	58.38	657.03	54.25	25.14	137.59	66.36	391.92	28.40	58.34	95.29	37.45	486.40	0.27	159.76	31.48	52.16	73.02	0.0	12.44
02-04-2016 24:00	16.92	47.89	93.37	49.06	633.70	56.45	26.96	125.19	58.58	383.86	28.49	28.38	90.44	35.83	442.88	0.36	226.10	30.29	47.50	64.24	0.0	16.08
01-04-2016 24:00	18.23	48.72	80.21	39.38	490.85	39.76	32.34	107.34	53.57	378.07	15.17	48.46	77.94	29.01	467.62	0.69	235.70	29.26	46.31	69.47	0.0	22.96
31-03-2016 24:00	20.83	55.70	121.88	62.83	450.63	53.71	30.88	140.16	72.61	412.86	13.35	86.62	95.44	40.23	467.41	0.45	264.32	28.71	46.87	77.06	0.0	23.44
30-03-2016 24:00	12.89	58.53	96.97	50.93	469.64	63.41	31.50	124.85	120.78	374.17	20.67	88.64	88.30	37.13	468.30	0.43	197.39	27.29	47.97	71.34	0.0	23.19
29-03-2016 24:00	7.16	35.71	21.85	25.02	486.87	37.79	30.56	91.06	45.25	322.10	19.17	57.30	66.69	19.19	430.57	0.27	260.83	25.79	48.36	67.63	0.0	12.53
28-03-2016 24:00	8.01	30.71	0.00	39.15	490.27	41.28	28.72	82.97	51.75	325.50	14.55	60.93	60.06	20.21	463.32	0.39	259.58	24.63	50.40	67.33	0.0	11.06
27-03-2016 24:00	7.06	29.60	0.00	28.95	482.06	32.90	27.35	66.21	33.76	315.87	14.21	OffScan	44.13	17.78	453.15	0.57	247.46	25.25	54.49	60.53	0.0	10.09
26-03-2016 24:00	7.89	32.17	0.00	30.28	484.50	27.53	30.19	110.83	61.29	323.10	20.40	OffScan	60.16	26.48	461.88	1.05	224.16	25.39	58.91	31.14	0.0	6.77
25-03-2016 24:00	7.44	31.62	0.00	38.94	539.30	14.86	32.19	88.55	47.37	350.99	13.37	OffScan	63.19	29.09	482.16	NoData	NoData	NoData	NoData	NoData	NoData	12.56

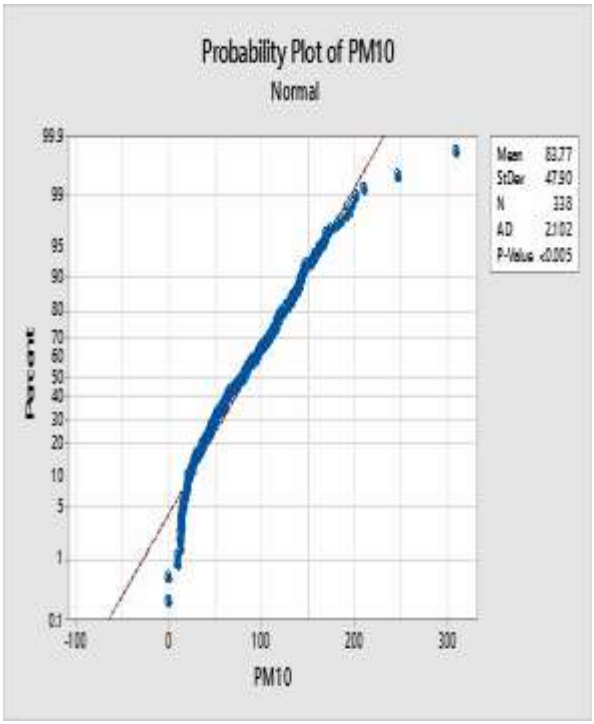
Analysis of PM10 and PM2.5 data (Using Minitab 17 software) - Run chart of PM 2.5 (Run chart shows the variation of data)

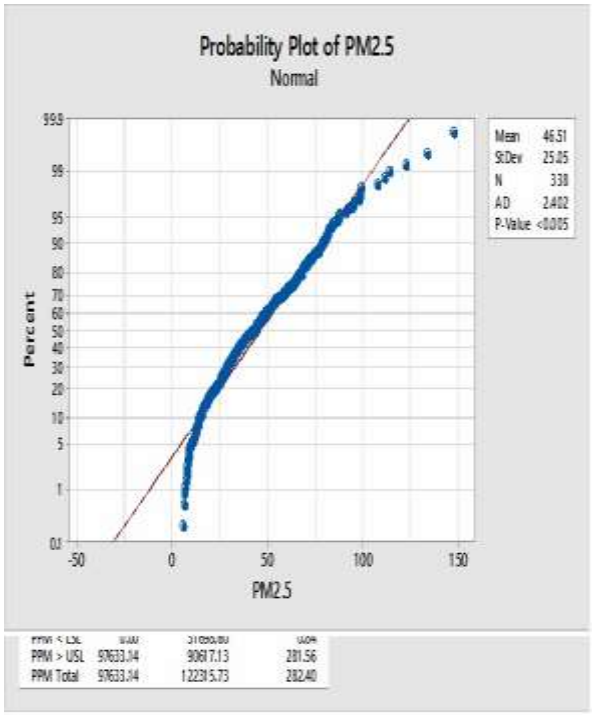


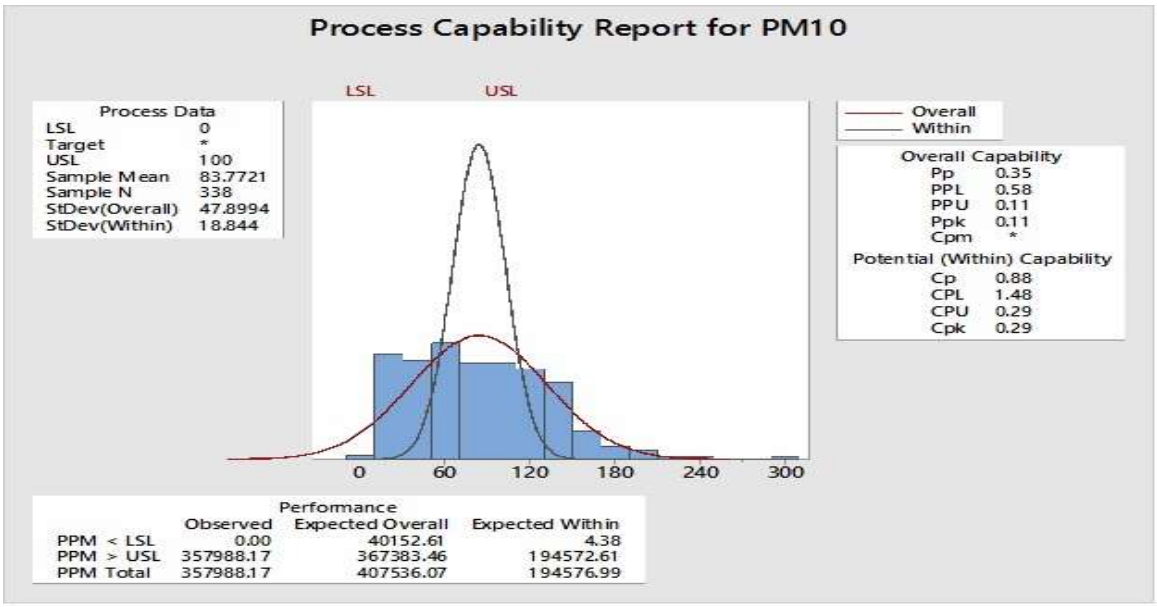
PM10 observation data



Probability Plot of data of PM10 and PM2.5 (As in both cases p-value is less than 0.005 so it shows both the datas obtained from NTPC Dadri AAQMS data follow normal distribution)

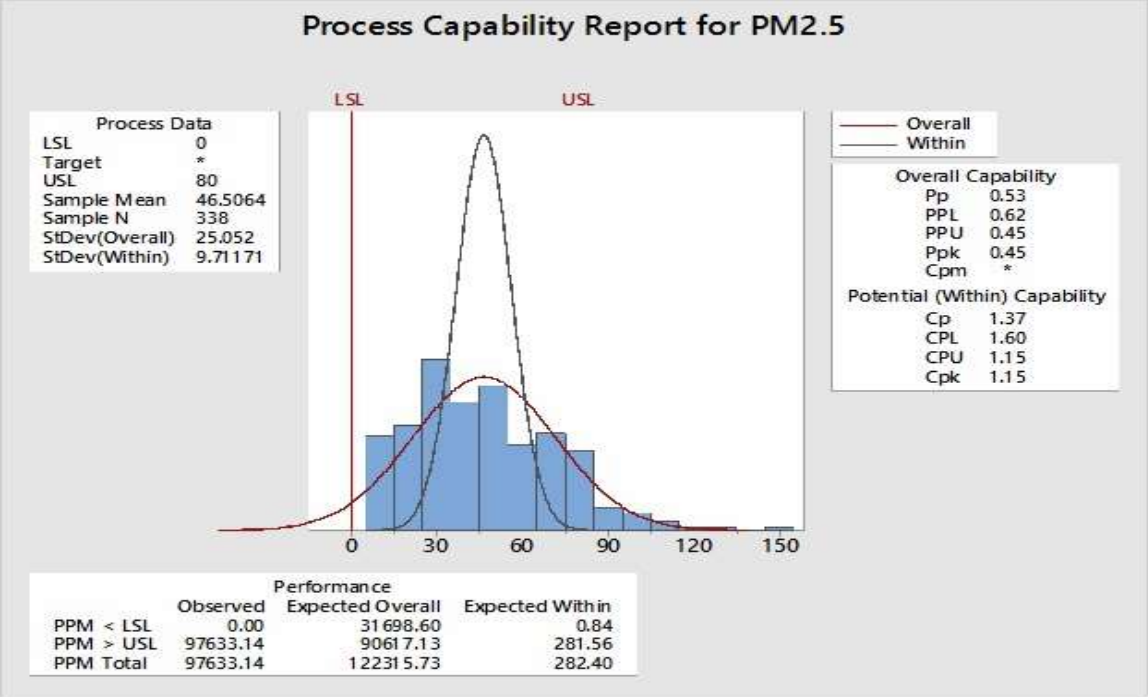






Sigma value = 3 * C_{pk}

Hence **Sigma level = 3 * 0.29 = 0.87 sigma level**



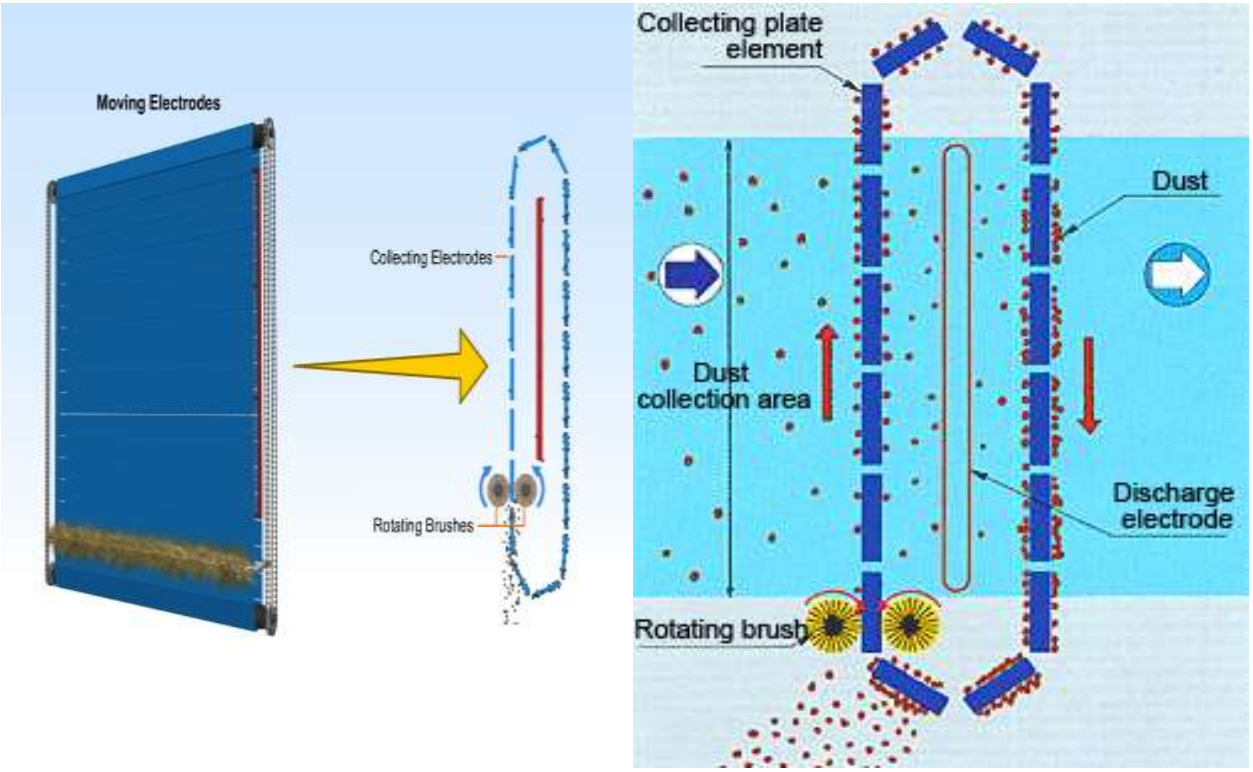
Sigma value = 3 * C_{pk} Hence Sigma level = 3 * 1.15 **= 3.45 sigma level**

So for 3.45 sigma level DPMO = 25587 (It means per million order 25587 times NTPC Dadri exceeds PM2.5 level defined by MOEF). Various positive points of Dadri thermal power plant in regard of Environment management: ESP performance is more than 99 % efficiency. , 100 % Ash utilization through NVVN (NTPC Vidyut Vyapar Nigam). Ash is getting used in filling purposes near evacuations in metro rail area, in construction of railway embankment, mine filling and ash based bituminous road., Own ash brick plant being used in making homes at township, Ash mound and plantation at that ash mound.

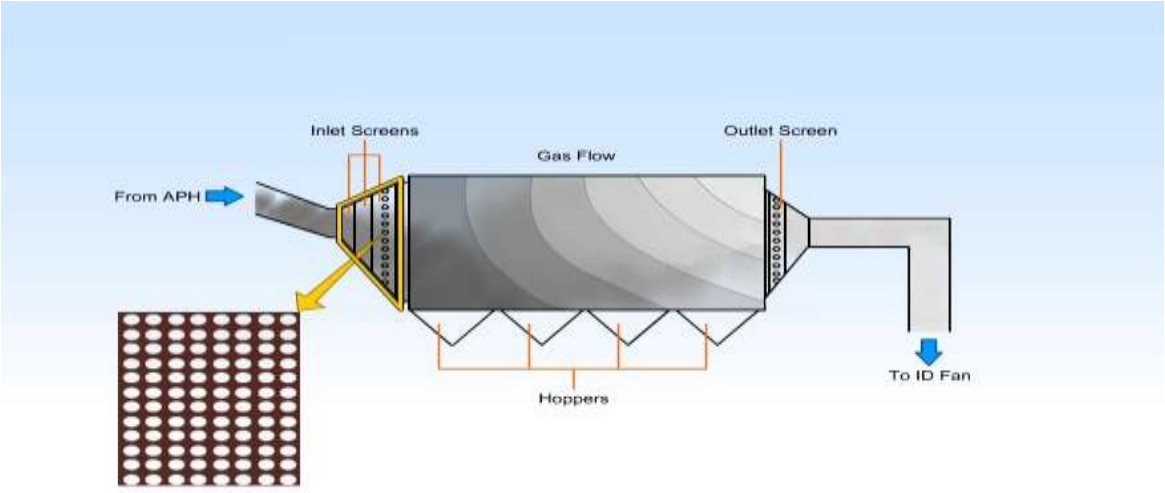
SPM parameters of Dadri at 26 Sep 2016 03.09 Hrs
Unit Load = 157 MW
NOx = 464 mg/Nm3
Sox = 1256 mg/Nm3
CO_2 = 11.197 % Volume
CO = 8.4ppm
Velocity = 6 m/s
FGT = 122 degree
Opacity = 40.3 mg/Nm3

Analysis and Recommendations:

1. **MEEP : (Moving Electrode ESP)** – Going to be implemented at Rihand and Korba. In last stage of ESP field to increase collection.



2. Skew Gas flow technology: (Flow of gas in skew pattern to increase residence time and decrease in flue gas velocity to improve collection efficiency)



3. NTPC has to go for power bundling in old plants (where PPAs are complete or about to complete) and promising in increasing RGO (renewable generation obligation) target

specified recently by ministry of power . **NTPC Dadri has put logic of all ESP off to unit trip in MFT logic**.In a similar way all plants of NTPC and state board plants should go for it.

4. The ambient SO_x and NO_x concentrations around the power plants are less than one-third the prescribed ambient air quality standard given. This is because the sulfur content of Indian coal varies within 0.3–0.6%, which is not considered significant. . The high emission levels are attributed due to high ash content of Indian coal but and overloading of the. Another reason may be due to the low sulfur content (0.8%) of Indian coal. ESPs are generally not very effective with coal containing less than 1% sulfur. The low sulfur content of Indian coals has negative effects on the performance of the ESPs.. A crucial reason that the Indian plants have failed to meet the standards is because the ESPs require regular maintenance, which the financially strapped power plants find difficult to do. Moreover, as there is no severe penalty for non-compliance, there is no incentive for the plants to maintain the ESPs. Since efficient working of the ESPs is the key factor for reduction of emissions, lack of maintenance is another reason why the power plants fall short of the ambient standard for clean air despite the installation of ESPs .
5. **From 2017, thermal power plants across India will have to cut particulate matter emissions by as much as 40 per cent.** Use of fabric filter in fluidized boilers in plants to be pondered. . CERC should also give special incentives for Retro fitment in ESP. BEE and CPCB department come together

CONCLUSION

For NTPC, “Going Higher on Generation, lowering Green House Gas Intensity” is vision statement on managing our environment. Since the genesis of the company, NTPC has led from the front on this issue. In November 1995, NTPC brought out a comprehensive NTPC Environment Policy and Environment Management System. Amongst the guiding principles adopted in the document are the company's pro-active approach to environment, optimum utilisation of equipment, adoption of latest technologies and continual environment improvement. The policy envisages new technology initiatives and efficient utilisation of resources, thereby minimising waste, maximising ash utilisation and ensuring a green belt all around the plant for maintaining ecological balance. We do not rest on our laurels and our work in this crucial and challenging issue is an ongoing one where we are constantly striving to reduce our impact further. We aim to be a global leader in environmental standards and practices. NTPC should make benchmarking standards in emission reduction, water consumption and clean energy adoption techniques so that we have proud to say , “Yes ! we have done it”.

REFERNCES

1. **NTPC Dadri intranet**
2. **www.moef.gov.in**
3. **www.cpcb.nic.in**