Assessment of Air Quality in and Around Raichur Thermal Power Station, Raichur

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Abstract- *Thermal power plant has led to significant degradation of ambient air quality due to the release of air pollutants from the combustion of fuel.*

Raichur Thermal Power Station uses coal as a fuel to produce electricity. The present study was carried out to assess the ambient air quality levels in respect of suspended particulate matter (SPM), SO_2 and NO_x in certain areas of Raichur Thermal Power Station, Raichur. The study was carried out for a period 45 days. The ambient air quality was monitored at three places in and around RTPS to give the representative data. The monitoring was done for 24hours for every 10days. Similarly stack monitoring was carried out for all the 8 units of RTPS with an interval of 10 days. The pollution control equipment used at RTPS was Electrostatic Precipitator. The performance study of this equipment was carried out. It was found to operating well with an efficiency of 99.8% and more. The dispersion of particulate matter follows the annual predominant wind direction of an area. Therefore, to identify any possible cause and effect relationship between pollutant levels and climate changes, meteorological parameters, such as temperature, relative humidity, wind speed and direction were also monitored simultaneously during the sampling period of air pollutants.

Maximal concentration of SPM are found in the sensitive area i.e., Hospital region due to the wind patterns and the concentration gradually diminished with increase in distance due to transportation, deposition and dispersion of particles. Also the concentrations of the sulphur dioxide and oxides of nitrogen were not meeting the standards for any of the stacks.

Key Words: Suspended particulate matter (SPM), SO_2, NO_x, stack, Electrostatic Precipitator, meteorological parameters, sampling period, etc.,

1. INTRODUCTION

Urbanization in India is more rapid around the major cities in India. Increase in industrial activities, population both endemic and floating and vehicular population etc., have led to a number of environmental problems, one of them being air pollution. Various contaminants continuously enter the atmosphere through natural and man-made processes and these contaminants interact with the environment to cause disease, toxicity, environmental decay and are labelled as pollutant. Air Pollutants means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures, plants, property, and environment. Air pollution is basically the presence of air pollutants in the atmosphere. The air has a relative constant composition of gases and is utilized by most of the living organisms in respiration to liberate chemical energy for their survival. This composition determines its quality and is being changed in the recent past due to emission of large amount of un-natural materials in the atmosphere by industries and automobiles. This changed quality became a great threat to survival of life, properties, materials and ecosystem as a whole.

In India, Industrial developments of urban centres have posed severe threat to air pollution due to uncontrolled emissions of pollutants into the environment. In the course of energy production, coal-fired power plants directly emit particulate matter (PM, sometimes called "soot") as well as gases that undergo chemical reactions to form fine particles in the atmosphere, such as SO_2 and NO_x. These emissions of PM, SO_2 and NO_x increase the ambient concentration of PM less than 2.5 microns in diameter ($PM_{2.5}$) over hundreds to thousands of kilo meters downwind of the plants. Exposure to $PM_{2.5}$ has been consistently linked with increased mortality from cardiopulmonary diseases, lung cancer, and numerous other respiratory illnesses and associated morbidity.

1.1 OBJECTIVES OF THE PRESENT STUDY

1. To determine the concentration of major pollutants viz., SO_2, NO_2 and SPM in the ambient air in and around RTPS.
2. To monitor the stack at different units of RTPS.
3. To study the performance of Electrostatic precipitator.
4. To compare the quality of the collected air sample with respect to the NAAQ standards.

2. INDUSTRY AND ITS DESCRIPTION

2.1 Introduction:

Raichur Thermal Power Station (RTPS) is a coal-fired electric power station located at 16°21′18″N 77°20′31″E 16.355°N 77.34194°E in the Raichur district of the state of Karnataka, India. It is operated by the Karnataka Power Corporation Limited (KPCL) and it accounts for about 40% of the total electricity generated in Karnataka. RTPS has eight units of 210MW each for units1-7 and 250MW for 8th unit and it is generating around 35-40 million units of energy/day. The process flow diagram of RTPS is given in figure 3.1.

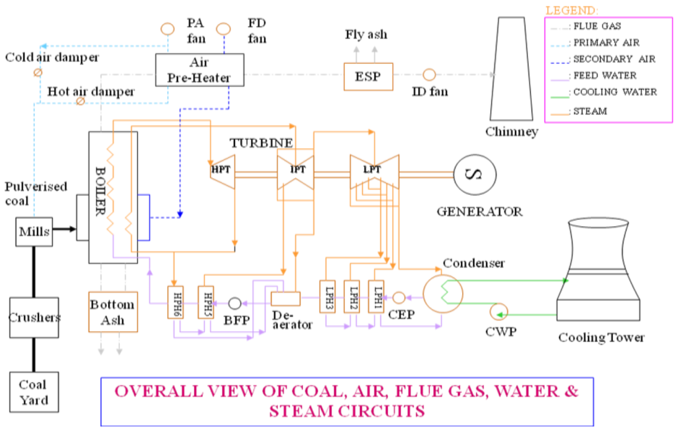

Fig -1: Flow diagram of RTPS.

2.2 Coal Handling System:

The total quantity of coal required is around 8.0 million tonnes per annum. The coal is received at RTPS by conventional box 'N" wagons. The present coal yard is capable of storing the coal for a period of 25 days comfortably as per the guide-lines of the Central Electricity Authority.

2.3 Raw Water & Water Treatment System:

Water required for the station is around 160-180m^3/day. Raw water supply to the plant as well for the colony is presently drawn from Krishna River through the existing intake pump house would be adequate. To ensure adequacy, and MOEF/KSPCB stipulations, treatment of waste water and recycling at the plant has been implemented. The station deploys re-circulating cooling water system to meet the cooling water requirement by adopting natural draft cooling towers. Make-up water supplied from raw water system is provided for condenser cooling. Eight natural draft cooling towers designed for a flow rate of 32,000m^3/hr per unit with a design cold water outlet temperature of 36 °C are provided.

2.4 Ash Handling System:

RTPS generates about 1.5 million tonnes of fly ash annually which causes environmental problems. 20% of the ash produced is wet bottom ash which is let into the ash bund. Ash removal is done by hydro-pneumatic/jet pumps. The bottom ash resulting from the combustion of coal in the steam generator is collected in the water impounded bottom ash hopper. The ash so collected is fed once in a shift of 8 hours to clinker grinder where it is ground. Fly ash is extracted sequentially from the hoppers located in the flue gas path by creating vacuum in the extraction circuit using high-pressure water pumped by vertical ash water pumps through ejectors or alternatively using vacuum pumps. The fly ash thus extracted is disposed of in wet form by mixing with water in wetting units and pumping the resultant slurry by ash slurry pumps to the ash disposal area.

An efficient electrostatic precipitator (collection in efficiency of about 99.89%) along with a properly designed boiler would keep the stack emission of particulate within acceptable limits.

As the sulphur content in coal is low (<0.4%), SO_2 generated during combustion would be nominal. Moreover, a stack height of 220 m would limit ground level concentration of SO_2 within acceptable limits by proper dispersion. With a properly designed furnace and burner system, generation of CO and NO_x would be minimized.

The station has been accredited with **ISO 14001 - 2004** for environmental protection management. To minimize emission of Suspended Particulate Matter (SPM) along with boiler flue gases Electrostatic Precipitators of adequate size with an efficiency of more than 99.93% is provided at exit end of the boiler to bring down SPM emission level under 100 mg/Nm^{3}All the unit contains single-flue RCC stack. The stack height details are as below.

Table -1: Stack heights of all the units

Stack	Height(m)
Unit 1&2	135
Unit 3-8	220

Fly ash production is of the order of 15 lakh tons per annum with 7 units in operation. A sizeable portion of fly ash is already being consumed by local cement industries, namely ACC Plant, Rajashree Cement and Vasavadatta Cement and local SSI units for manufacture of fly ash bricks.

3. MATERIALS AND METHODS

3.1 General

The scheme of experimental methodology was formulated to investigate the potential concentration of criteria pollutants i.e., SPM, SO_x , NO_x for a period of 45 days from 20/10/2011 to 5/12/2011 in and around RTPS, Raichur.

3.2 Ambient Air Quality Monitoring

The ambient air quality monitoring was carried out at three places Main plant station building (Industrial area), RTPS Hospital (Sensitive area), River water intake point (Restricted area) considering different criteria's for selecting the sampling stations. The sampling was done for three trials.

For the analysis of SPM and RSPM Aero Vironment's "Respirable Dust Sampler Model RDS9000" instrument was and sampling was carried out for 24hrs.

For the analysis of sulphur dioxide ambient air is injected into impinger of the instrument "Respirable Dust Sampler Model RDS9000" having absorbent which is taken for chemical analysis after sampling After 30mins of reaction, absorbance is measured at 548nm. SO_x concentration is determined using standard graph of absorbance against concentration.

Analysis of oxides of nitrogen is same as SO_2. Here the solution is kept for 15min for reaction to complete and absorbance is measured at 540nm. NO_x concentration is determined using standard graph of absorbance against concentration.

3.3 Stack Monitoring

The sampling for the analysis of SPM is carried out using the stack monitoring kit of Aero Vironment. The sample is drawn at the calculated flow rate for 20mins. The initial and final weight of thimble is taken and the weight of dust collected is found.

The SO_x and NO_x in the stack are measured using the "Quintox Flue Gas Analyser". The probe which senses the flue gases in the stack is connected to the instrument.

The sampling was done for all the 8 units of RTPS and it was carried out for three trials during the study period 20/10/2011 to 5/12/2011.

Table -2: Testing Procedure

Sl. No.	Pollutants	Unit of Measurement	Sampling Frequency	Methods and Instrument Adopted
Ambient Air Quality Monitoring				
1.	SPM	mg/Nm³	24 hourly every 10 days	Gravimetric (High-Volume)
2.	RSPM	mg/Nm³	24 hourly every 10 days	Gravimetric (High- Volume with Cyclone)
3.	SO_2	mg/Nm³	24 hourly every 10 days	Colorimetric
4.	NO_2	mg/Nm³	24 hourly every 10 days	Colorimetric
Stack Monitoring				
1.	SPM	mg/Nm³	20 min	Stack Monitoring Kit
2.	SO_x	mg/Nm³	-	Quintox Flue Gas Analyser
3.	NO_x	mg/Nm³	-	Quintox Flue Gas Analyser

Table -3: Meteorological data during the study period

Date	Temperature Deg C		Humidity %			Relative Humidity	Wind Speed M/S	Wind Direction	Rainfall Mm
	Min	max	Dry	Wet	Diff				
20/10/211	37	22	18	15	3	53	1.3	EW	-
21/10/11	37	24	28	16	12	55	1.0	NS	-
22/10/11	38	22	19	16	3	61	1.2	EW	-
24/10/11	37	24	18	15	3	63	1.3	NS	-
26/10/11	37	27	25	17	7	64	2.0	ES	5.6
28/10/11	39	29	27	15	12	77	0.4	NS	-
29/10/11	38	27	29	21	8	71	2.8	EW	-
31/10/11	35	23	29	15	29	58	1.0	NS	-
2/11/11	34	22	26	15	11	71	2.3	EW	-
3/11/11	35	23	27	15	12	62	1.5	ES	-
4/11/11	35	20	27	15	12	63	1.7	EW	-
6/11/11	37	18	26	14	12	79	2.2	EW	-
7/11/11	36	23	26	14	12	65	0.9	EN	-
9/11/11	28	18	23	10	13	69	2.5	NS	-
10/11/11	35	13	26	18	8	72	1.4	EW	-
11/11/11	35	17	26	13	13	55	1.3	NS	-
15/11/11	35	23	27	10	17	73	1.0	SN	-
16/11/11	35	16	23	10	13	78	1.5	SN	-
19/11/11	33	11	25	16	9	59	1.4	EW	-

21/11/11	36	12	25	16	9	65	1.5	NS	-
22/11/11	34	16	25	12	13	70	0.6	NW	-
23/11/11	33	12	25	18	7	67	1.0	NS	-
24/11/11	33	18	24	12	13	70	2.0	NE	-
25/11/11	35	22	25	14	11	59	0.6	NE	-
27/11/11	32	19	24	14	10	72	3.0	NE	1.5
28/11/11	31	21	26	14	12	71	2.8	NS	-

4. Results and Discussion

The results of analysis of the air pollutants at an interval of 10 days duration has been tabulated in the following different tables for a period of 45 days (from 20/10/2011 to 5/12/2011).

4.1 Results of Stack Monitoring:

Table -4: Stack emissions for unit 1-7

	Unit-1			Unit-2			Unit-3			Unit-4		
Parameter mg/Nm^3	SPM	SOx	NOx	SPM	SOx	NOx	SPM	SOx	NOx	SPM	SOx	NOx
1st set	91.04	1397	50	82.58	307	265	54	48	11	96.3	303	209
2nd set	89.2	2095	464	56.88	294	247	90.48	1398	550	41.3	242	213
3rd set	*	*	*	68	355	300	61.95	1027	434	112	1221	217
Avg	90.12	1746	507	69.15	319	271	68.81	824	332	83.2	589	213

	Unit-5			Unit-6			Unit-7		
Parameter mg/Nm3	SPM	SOx	NOx	SPM	SOx	NOx	SPM	SOx	NOx
1st set	112	520	416	108	753	201	145	570	320
2nd set	43.7	1296	440	162.6	699	239	79	886	301
3rd set	88.75	827	310	142.7	775	230	*	*	*
Avg	81.48	881	389	137.7	742	223	112	728	310

*the unit was shut down during that day of trial.

Table -5: Stack Emission values minimum and maximum for the study period

Parameter mg/Nm3	SPM		SO_x		NO_x	
	Min	Max	Min	Max	Min	Max
Unit-1	89.2	91.04	1397	2095	50	464
Unit-2	56.88	82.58	294	355	247	300
Unit-3	54	90.48	48	1398	11	550
Unit-4	41.3	112	242	1221	209	217
Unit-5	43.7	112	520	1296	310	440
Unit-6	108	162.2	699	775	201	239
Unit-7	79	145	570	886	301	320

The table shows that Unit-6 has a maximum SPM value of 162.2mg/Nm^3 during second trial which is exceeding the limit, 150mg/Nm^3. The reason for higher concentration of SPM in the stack may be due to incomplete combustion of coal or lesser residence time (<34 seconds) of flue gases in the ESP which caused the gases to move out of ESP before treating them. The table also clearly shows that all other units are within the limit range.

The concentration of SO_x and NO_x are crossing the limits for all the units. The reason for these high concentrations may be due to usage of unwashed coal, high sulphur content of coal and combustion process presently implemented such as high excess air.

4.2 Results of Ambient Air Quality Monitoring:

Table -6: Ambient Air Quality Monitoring

	AAQM-1				AAQM-2				AAQM-3			
Param eter Mg/N m3	TSP M	RSP M	SO 2	N O2	TSP M	RSP M	SO 2	N O2	TSP M	RSP M	SO 2	N O2
1st set	130	25. 4	28	32	112	36. 24	24	20	39	19	26	28
2nd set	93	58. 2	26	22	10. 98	4.0 6	19	17	41. 3	20	24	20
3rd set	96. 5	63. 8	20	17	11. 87	4.5 5	20	15	47	23	20	17
Avg	106 .5	49. 1	25	24	44. 95	14. 95	21	17	42. 4	21	23	22
Limits	100	75	30	35	500	150	12 0	12 0	200	100	80	80

AAQM-1----Hospital

AAQM-2----Station building

AAQM-3----Intake

Table -7: Ambient Air Quality Monitoring values min and max for the study period

Parameter mg/Nm3	AAQM-1		AAQM-2		AAQM-3	
	Min	Max	Min	Max	Min	Max
TSPM	93	130	10.98	112	39	47
RSPM	25.4	63.8	4.06	36.24	19	23
SO2	20	28	19	24	20	26
NO2	17	32	15	20	17	28

The table shows that during 1st trial TSPM values for AAQM-1 i.e., Hospital region (Sensitive area) is exceeding the limit due to dispersion patterns and all other pollutants are within the range for all regions.

4.3 Results of Performance Study of Electrostatic Precipitator:

Table -8: Details of electrostatic precipitators of unit 1 to 8

Sl. No	Design parameters	Unit-1&2	Unit-3	Unit-4	Unit-5&6	Unit-7	Unit-8
1.	Type of ESP	2FAA-6X32-11190-2	FAA-6X45-2X90125-2	FAA-6X45-2X84125-2	FAA-6X45-2X96125-2	FAA-6X45-2X96125-2	FAA-6X45H-2X120135-2
2.	Specific Collecting Area (SCA)	147.32 m2/m3/sec	227.53 m2/m3/sec	209.37 m2/m3/sec	226.80 m2/m3/sec	226.80 m2/m3/sec	316.44 m2/m3/sec
3.	Gas flow rate	347.2 m3/Sec	356 m3/Sec	353.88 m3/Sec	380.93 m3/Sec	380.93 m3/Sec	449.5 m3/Sec
4.	FG Temperature	140 deg C	138 deg C	134 deg C	150 deg C	150 deg C	127 deg C
5.	Dust concentration	30.2 gm/Nm3	67.5 gm/Nm3	55.42 gm/Nm3	83.36 gm/Nm3	83.36 gm/Nm3	83.28 gm/Nm3
6.	No. of Gas paths per Boiler	FOUR	TWO	TWO	TWO	TWO	TWO
7.	No.of field in series	SIX	SIX	SIX	SIX	SIX	SEVEN
8.	Guanteed Collection Efficiency (GCE)	99.37 %	99.78 %	99.83 %	99.82 %	99.82 %	99.87 %
9.	Pressure drop across the ESP	18 mmWC	18 mmWC	18 mmWC	20 mmWC	20 mmWC	20 mmWC
10.	Velocity of gas at Electrode zone on total area	0.87 m/sec	0.791 m/sec	0.85 m/sec	0.79 m/sec	0.79 m/sec	0.57 m/sec
11.	Treating time	22.1 Sec	34.13 Sec	34.13 Sec	34.18 Sec	34.18 Sec	55.37 Sec

The performance study of the Electrostatic Precipitator clearly shows that the all the ESP's of all the units are more than 99.37% efficient.

Table -9: Details of Collecting Electrode (CE)

1	No. rows of CE per field.	38	61	61	65	65	81
2	No. of CE per field.	304 (8 plates / row)	366 (6 plates / row)	366 (6 plates / row)	390 (6 plates / row)	390 (6 plates / row)	486 (6 plates / row)
3	Total No. collecting electrode	7296	4392	4392	4680	4680	6804
4	Nominal height of CE	9 mtrs	12.5 mtrs	12.5 mtrs	12.5 mtrs	12.5 mtrs	13.5 mtrs
5	Nominal width of CE	400 mm	750 mm	750 mm	750 mm	750 mm	750 mm

Table -10: Details of Emitting Electrode (EE)

1	Type of E	Spiral with hooks	Spiral with hooks	Spiral with hooks	Spiral with hooks	Spiral with hooks	Spiral with hooks
2	Size of E	2.7mm	2.7mm	2.7mm	2.7mm	2.7mm	2.7mm
3	No. of E per field	1184	3240	3240	3456	3456	4320
4	Total No. of E	28416	38800	36288	41472	41472	60480
5	E spacing plate / wire	150mm/125mm	150mm/250mm	150mm/250mm	150mm/250mm	150mm/250mm	150mm/300mm
6	CE rapping hammer weight	6.3 Kg	4.9 Kg	4.9 Kg	4.9 Kg	4.9 Kg	4.9 Kg
7	EE rapping hammer weight	4.9 Kg	3.0 Kg	3.0 Kg	3.0 Kg	3.0 Kg	3.0 Kg

E-Electrode

5. Conclusions and Recommendations

5.1 Conclusion

Based on the analysis carried out during the study period the following conclusions can be drawn:

1. The concentrations of Suspended Particulate Matter (SPM) are all within the prescribed NAAQ limits except at the Hospital region.

2. The concentrations of Sulphur Dioxide (SO2), Oxides of Nitrogen (NO_x), Respirable Particulate Matter (RSPM) at all the locations is within the prescribed limits when ambient air quality monitoring was done.

3. It can also be concluded that the SPM concentrations for all 7 units are within the NAAQ standards.

4. The SO_x concentration and NO_x concentrations are all exceeding the limits for all the units.

5. It can be concluded that the Electrostatic Precipitator (ESP) of all the units is performing well with an efficiency of more than 99.78%.

5.2 Recommendations to Reduce the Air Pollution

1. Equally stringent emission norms for industries need to be enforced for mitigation of air pollution.

2. It is advocated to develop a green belt in the polluted region of the cities as one of the control measures.

3. The SO_x emissions can be controlled by coal washing/beneficiation and by providing sulphur removal plant at the pre-combustion stage.

4. During the combustion stage by adding the limestone the production of SO_x can be limited.

5. And also by providing Flue Gas Desulphurization (FGD) plant at the emission ends, the emission of SO_x into the air can be reduced.

6. NO_x emissions can be controlled by combustion modification: low-NO_x burners with or without over fire air or re-burning, water/steam injection, and selective catalytic or non-catalytic reduction (SCR/SNCR).

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