

## **Atmospheric Emission Inventory for Criteria Pollutants of Coal Fired Thermal Power Plant**



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### **Abstract:**

Air emissions inventory is the foundation for assessment of air quality impact. Developing a sound emissions inventory is a prime task and requires a collation of significant amount of data. Emissions inventory of a premise is useful to identify all kinds of sources of air pollution and the quantity of air pollutants emitted from each source. It is also useful to compute and estimate the emission concentration and the rate of air pollutants emitted. In the present study, we made a stock of emission discharge of criteria pollutants of Suspended Particulate Material (SPM), Sulphur dioxide (SO<sub>2</sub>), and Nitrogen oxides (NO<sub>x</sub>) from stationary source of a 1050 MW thermal power plant (Rayalaseema Thermal Power Plant, Kadapa, Andhra Pradesh, RTPP) was prepared from fuel utilization and outflow database. The strategies utilized for inventory presentation are supplier's specifications and direct Measurements. Emission factors were calculated for SO<sub>2</sub> and NO<sub>x</sub> and the results are compared from two strategies.

### **Keywords:**

Thermal power plant, emission inventory, criteria pollutants, assessment.

### **INTRODUCTION: Emissions inventory:**

The primary task of air emission inventory [1] is to identify different types of sources and quantities of emissions of air pollutants from a given project premises. It will also give a brief description of the physical and geographical conditions of the sources of emissions. More reliable data can be produced regarding emission rates and emission concentrations. Systematic procedure to be followed for emission inventory is as follows:

### **Source identification:**

A complete knowledge of the premises is essential to develop emissions inventory. Undertaking a site visit of the existing premises or a detailed review of the engineering drawings of the proposed premises is quite necessary to identify all sources of air pollution. Thus the information can be supplemented with the existing literature on the industry and its most prevalent air pollution issues. For all sources of air pollution at premises, the following are identified:

- » Release type
- » Location (in meters relative to fixed origin, elevation and discharge geometry)
- » Potential air pollutants emitted.

### **Release type:**

Point sources, five stacks are identified with 220 m tall and 4 m diameter at the exit. These stacks emit flue gases in to the atmosphere forcefully above ground level. These are considered as tall point sources.

### **Wake free point sources:**

Wake-free point sources are more than 2.5 times the height of the largest nearby buildings, so that surrounding buildings do not influence the stack top airflow.

### **Location:**

Andhra Pradesh state electricity board set up a Thermal power station at Kalamala with an installed capacity of 1050 Mw. It is established with five units under three stages. Each unit generates 210 Mw of power.

The site of Rayalaseema Thermal Power Project at Kalamala is located at a distance of 15Km from Yerraguntla, 20Km from Proddutur, 45Km from jammalamadugu and 8Km from Muddanur railway station which is situated on Chennai-Guntakal Broad gauge line. The project site is at 180 m above MSL and is far away from any forest boundary. It lies on latitude of 14o – 42’-30’’N and longitude of 78o-28’ E. The project is located in an area of 1650 Hectares. Figure 4.1 depicts the location of the power plant where the study is carried out.

### RTPP Background:

Andhra Pradesh state electricity board set up the Thermal power station at kalamala with an installed capacity of 1050 Mw. It is established with five units under three stages. Each unit generates 210 Mw of power. Table 1 gives the basic details regarding the capacity of the plant. Criteria air pollutants emitted Criteria air pollutants from the source are: Suspended Particulate Materials (SPM), Sulfur dioxides (SO<sub>2</sub>), and nitrogen oxides (NO<sub>x</sub>) from stationary source of a thermal power plant. Ozone also produced as secondary pollutant from its precursors. All the pollutants produced are considered as photo toxicants [6]. They will show severe environmental impact on man, material, livestock and vegetation.



**Fig 1: Rayalaseema thermal power plant – location map**

Stations	Units	Capacity(MW)	Date of commissioning
Station-I	Unit 1	210	31-03-1994
Station -II	Unit 1	210	25-02-1995
Station-III	Unit 1	210	25-01-2007
Station-IV	Unit 1	210	20-11-200
Station-V	Unit 1	210	29-11-2010
<b>Total</b>		<b>1050</b>	

**Table1: Installed capacity of power plant**

### Methods for the Estimation of Emission Rates

There are number of methods [7] for estimation of emission rate and emission concentration from each source. In the present investigation direct measurement, Supplier’s Specifications and Emission factors are used for emission inventory.

### Supplier’s Specifications :

RTPP is linked with Singareni Collieries Co., Ltd., for supply of coal. This company has a proven coal resource of around 4000 million tones with 70 % extractability. This company has sufficient coal reserves to produce 30000 MW of electricity for 25 years. Annual coal requirement is calculated on the basis of calorific content (Gross Calorific Value, GCV) of the coal supplied and was obtained as the following:

- a) GCV of Coal: 3686 Kcal/kg.
- b) Coal requirement for 220 Mw: 137 Tph.

Coal consumption for 5 units = 137 × 5 = 685 Tph.

Coal consumption for 5 units/year = 685 × 24 × 365 = 6000600 Tpy

Supplier’s specifications i.e. ultimate analysis of Singareni coal was obtained to estimate the rate of emission of criteria air pollutants from identified sources and is as presented in Table 2

Parameter	Mean Value
Hydrogen	2.74 %
Carbon	37.73 %
Nitrogen	0.74 %
Sulfur	0.44 %
Ash	44.84 %
Oxygen	7.34 %
Gross Caloric Value	3686 Cal/Kg

**Table 2: Typical Ultimate Coal Analysis.**

From the ultimate analysis, calculations were made to obtain emission of combustion related criteria air pollutants for combustion of 685

Tons of coal per hour and the results as furnished by RTPP are presented in Table 3

Combustion Product	Total Emission Rate
SO <sub>2</sub>	3973 kg/h
NO <sub>x</sub>	254.1 kg/h
H <sub>2</sub> O	9.232 %
O <sub>2</sub>	3.837 %

**Table 3: Calculated emissions of air pollutants from coal combustion**  
Coal combustion calculation results

The following Table 3 shows the results obtained from coal combustion calculated for the 685 Tons of coal per hour.

### Direct measurement:

In Rayalaseema thermal power plant Emission rates and source release parameters are established from the consequences of source emission online flue gas monitoring system direct pc based automation system for monitoring & recording facility capable of observing O<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, gas, stack temperature, excess air, combustion efficiency system provided with all the obliged accessories as obliged install after economizer and near id fan, to make the completely practical. Programmed pipe gas testing & filtration system, mounted in climate evidence ip55 secured enclosures SPM is evaluated by gravimetric strategy. Pollutant emission rates are straightforwardly measured from the stack by utilizing continuous monitoring system.

Source	Source type	Height of the stack(m)	Exit Temperature of Flue gas (°C)	Diameter of the stack (m)	Exit Velocity (m/S)	O <sub>2</sub> (%)	H <sub>2</sub> O (%)	Flow rate (Am <sup>3</sup> /S)	Flow rate (Nm <sup>3</sup> /S)
Stack-1	Wake-free point source	220	140	4	28.1	4.5	9	3.67	360
Stack-2	Wake-free point source	220	140	4	28.52	4.6	10	3.46	338
Stack-3	Wake-free point source	220	140	4	29.9	4.2	9.3	3.54	346
Stack-4	Wake-free point source	220	140	4	28.3	4.4	9.8	3.28	321
Stack-5	Wake-free point source	220	140	4	28.7	4.4	9.6	3.16	309

**Table 4: stack source release parameters**

All the parameters needed for the presentation of emission inventory are measured straightforwardly at the source. This system is more appropriate and reliable in emission inventory. Direct measurements include all stack release parameters specified in Table 4.

$$C_p = \frac{ER_p}{FR} \quad \text{---} \quad 1$$

### Calculation of pollutant concentration for Point Sources:

Concentration of Pollutant released from a point source is calculated using the equation given below as

Where:

C<sub>p</sub> = Concentration of pollutant p emitted in mg/m<sup>3</sup>

ER<sub>p</sub> = Rate of emission of pollutant p in mg/s

FR = Flow rate of flue gas in m<sup>3</sup>/s

Emission inventory can be expressed in terms of two types of emission concentrations:

1. Actual concentration of a pollutant released from a source in mg/Am<sup>3</sup>. It is calculated from the measured gaseous volumetric flow rate (Am<sup>3</sup>/s) and measured emission rate.

2. Actual pollutant concentration released from a source is corrected to the normal conditions in mg/Nm<sup>3</sup>. This is calculated using the gaseous volumetric flow rate corrected to normal conditions (dry, 273K, 101.3 kPa). Emission Concentration of criteria pollutants calculated from different stacks is presented in Table 4

Source	Pollutant	Emission rate (gm./s)	Corrected concentration (mg/Nm <sup>3</sup> )	Regulated concentration (mg/Nm <sup>3</sup> ) at stack reference conditions
Stack -1	SPM	38.33	106	150
	Sulfur dioxide	184	512	NA
	Nitrogen oxides	13.12	36.44	NA
Stack -2	SPM	36.62	108	150
	Sulfur dioxide	172	508	NA
	Nitrogen oxides	15.8	46.74	NA
Stack -3	SPM	25.95	75	150
	Sulfur dioxide	171.5	495	NA
	Nitrogen oxides	15.4	44.50	NA
Stack -4	SPM	24.22	75	150
	Sulfur dioxide	161.25	502	NA
	Nitrogen oxides	12.9	40	NA
Stack -5	SPM	27.61	89	150
	Sulfur dioxide	153.4	496	NA
	Nitrogen oxides	12.9	41.74	NA

**Table 5 Stack Emission Concentration of criteria pollutants calculated from different stacks  
Total Emission Rates and Concentrations**

Emission product	Emission rate (Supplier's specifications)	Emission rate (Direct measurement)
SPM	----	549.82 kg/h
SO <sub>2</sub>	3973 kg/h	3031.74 kg/h
NO <sub>X</sub>	254.1 kg/h	252.43 kg/h
H <sub>2</sub> O	9.232%	9.54%
O <sub>2</sub>	3.837 %	4.42%
GCV	3698	3686

**Table 6: Total Emission Rates and Concentration**

Emission product	Emission rate (Supplier's specifications)	Emission rate (Direct measurement)
SPM	----	549.82 kg/h
SO <sub>2</sub>	3973 kg/h	3031.74 kg/h
NO <sub>X</sub>	254.1 kg/h	252.43 kg/h
H <sub>2</sub> O	9.232%	9.54%
O <sub>2</sub>	3.837 %	4.42%
GCV	3698	3686

**Table 7 Comparison of emission rates**

$$\text{Emission factor (EF) for SPM} = \frac{\text{ER}}{\text{Coal burns/day}} \text{ ----- 2 (Emission control 99.5\%)}$$

$$\frac{549.82}{685} = 0.802$$

$$\text{Annual emission rate (ER annual)} = \text{EF} \times \text{annual coal burns} \text{ -----3}$$

$$\text{Annual emission rate (ER annual)} = 0.802 \times 6000600 = 4816 \text{ Tpy}$$

$$\text{Emission factor (EF) for SO}_2 = \frac{\text{ER}}{\text{Coal burns/day}} \text{ ----- 4}$$

$$\frac{3031.74}{685} = 4.42$$

$$\text{Annual emission rate (ER annual)} = 4.42 \times 6000600 = 26522 \text{ Tpy}$$

$$\text{Emission factor (EF) for NO}_X = \frac{\text{ER}}{\text{Coal burns/day}} \text{ -----5}$$

$$\frac{252.43}{685} = 0.368$$

$$\text{Annual emission rate (ER annual)} = 0.368 \times 6000600 = 2211 \text{ Tpy}$$

The emission factors calculated can be used to quantify emissions of various power plants using coal from Singareni Collieries Co., Ltd., depending on the coal burns annually.

### Comparison of Emission inventory:

Comparison of Emission inventory by supplier's design specification and direct measurements calculation results of total emission rates [7] of different combustion products are represented in Table 7.

## CONCLUSION:

This study gave all fundamental data and information needed for air pollution modeling, and clearly depicted the details of site specific conditions. Emission rates of criteria pollutants and other combustion products are presented from two methods, Supplier's specifications and direct measurement. Direct measurement is more accurate methodology for the development of emission inventory for coal combustion thermal power plants. The results observed from supplier's specifications and direct measurements are comparatively equal. Here sulfur dioxide values are little difference due to incomplete combustion of coal. Emission rates provided can be applied for environmental modeling and for environmental impact assessment for criteria pollutants for future estimation. If emission data is not accessible for that specific power project. Annual emission rates are provided from emission factors and annual activity.

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