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Emissions Inventory and Emission factors for Cement Industry

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Abstract : Emissions inventory is the foundation of air quality impact assessment. Developing a sound emissions inventory should be the prime task and requires a collation of a significant amount of data. The emissions inventory for the premises is useful to identify all kinds of sources of air pollution and the air pollutants emitted from each source. It is also useful to compute and estimate the emission concentration and the rate of air pollutants emitted. The current investigation deals with an emission inventory for the Criteria air pollutantsof Suspended Particulate Matter (SPM), Sulfur oxides (SO_2), and Nitrogen oxides (NOx) from stationary sources in cement industry, which will show the severe environmental impact on man, material, livestock and vegetation. Emission database was developed for Ultra Tech Cement Ltd Bhogasamudram, Andhra Pradesh, India. Emission factors are calculated for the pollutants. The methods used for inventory presentationare Manufacturers' design specifications and direct measurement. The results observed from supplier's specifications and direct measurements are comparatively equal. Here Sulfur dioxide and Nitrogen oxides values are little difference due to incomplete combustion of coal.
Keywords : cement industry; Emission inventory; Criteria pollutants; emission concentration; Impact assessment.

Introduction:

Emissions Inventory

The emissions inventory, is the primary task to identify the various sources of pollution from the particular plant (Anand Kumar Varma S, 2014). It provides the physical and geographical conditions of the source of pollutant. More reliable data can be produced, regarding emission rates and emission concentrations (EMEP/EEA air pollutant emission inventory guidebook).

Source identification

For the Emission inventory development source identification is essential (Barclay J, 2005).Systematic procedure of emission inventory involves the source identification which includes:

- Release Type
- Location
- Emission of criteria air pollutants

Release Type

Point sources, in view of source type three stacks are identified as shown in Table 1.These stacks emit flue gases into the atmosphere forcefully above ground level (Bonnie N, 2004). These are considered as tall point sources.

Table 1. Stack details of UTCL

Stack	Height of the stack	Diameter of the stack
Stack 1	150	6.5
Stack 2	180	7.5
Stack 3	210	7.5

Wake – Affected Point Sources

There are no nearby buildings or other structures to interfere with the plume rise and dispersion. The point source is absolutely wake free source.

Location

Ultra Tech Cement Ltd Andhra Pradesh Cement Works is located at Bhogasamudram, 16 km fromTadipatriMandal in Anantpur district, Andhra Pradesh, India. Cement plant is located on the hilltop (351.5 m. MSL) and the packing plant & wagon tippler are located down the hill (266.0 m. MSL). The plant is located on the border line between Kurnool&Anantapur districts, 70 km from Anantpur city. The nearest railway station is "Juturu" between Tadipatri&Gooty on the Guntakal-Chennai line. The grinding unit is located in Arakkonam in the Tamilnadu state. This unit is not producing the clinker and it is taking the clinker from APCW and manufacturing OPC and PPC.

Criteria Air Pollutants Emitted

Criteria air pollutants from the source are: Suspended Particulate Matter (SPM), Sulfur Oxides (SO_x), Nitrogen Oxides (NO_x) from stationary sources of a cement industry.They will show the severe environmental impact on man, material, livestock and vegetation (Compilation of Air Pollutant Emission Factors, 1995).

Methods for the Estimation of the Emission Rates

There are a number of methods for the estimation of the emission rate and emission concentration from each source (ENDS Report 336, 2003).In the present investigation,

- Manufacturer's design specifications,
- Direct measurement and
- Emission factors

are used for emission inventory.

Manufacturer's design specifications

Manufacturer's design specifications are developed from the composition of coal in order to estimate the emission rates of air pollutants from the identified sources (Emission estimation technique manual for fossil fuel electric power generation 1999). The quality of coal that influences emission rates and emission concentrations of flue gas,the required coal to operate the UTCL is supplied by Singareni Collieries Co., Ltd. Hence manufactures design specifications are developed from the composition of Singareni Collieries Co., Ltd.TypicalUltimate Coal Analysis is presented in the table 2.

Table 2. Ultimate Analysis of Coal

Parameter	Mean Value
Hydrogen	3.3-3.61 %
Carbon	42.6-49.2%
Nitrogen	0.24-0.7%
Sulfur	0.4-0.5 %
Ash	24.9-43.0%
Oxygen	11.5-12.66%
Gross calorific value	3128-4577K Cal/Kg

Fuel (Coal)

Annual coal requirements are calculated on the basis of parameter of the coal and are given by:

a) Coal HCV of 4000 Kcal/kg.
b) Coal consumption 123Tph.

Coal consumption of 3 units = 123× 3 = 369 Tph.
Coal consumption of 3 units = 569×24×365= 3232440 Tpy.

Coal Combustion Calculation Results

The table 3 shows the results obtained from coal combustion calculated for the 369 Tons of coal per hour.

Table 3. Calculated combustion products

Combustion Product	Total emission rate
SO_2	2473 kg/h
NO_X	3014.1 kg/h
H_2O	9.232 %
O_2	3.837 %
GCV	3850cal/kg

Direct measurement

The coal combustion products estimation during the operation of the plant is given by the emission rates and source release parameters at UTCL are established based on the source emission online flue gas monitoring system (Continuous Emissions Monitoring Systems Data). It is a direct PC based automation system for monitoring & recording facility, Which is capable of monitoring O_2, CO, SO_2, NOx, CO_2 gas, stack temperature, excess air, the combustion efficiency system provided with all the required accessories as required installation after economizer and near id fan, to make it fully functional (Granholm JM).

Computation of Flue Gas Concentration for Point Sources

The pollutant concentration computation which is released from a source is given mathematically as:

$Cp = ERp/FR$…….(1)
Where:
C_p=the concentration of pollutant p emitted in mg/m^3
ERp= the rate of emission of pollutant p, in mg/s
FR = the flow rate of flue gas in m^3/s

Stack release parameters are presented in table 4. The emission inventory may be expressed in two forms of emission concentrations they are given as:

1. The actual concentration of a pollutant released from a source in mg/Am^3. It is calculated from the measured gas volumetric flow rate (Am^3/s) and measured emission rate (table 5).
2. Actual pollutant concentration released from a source is corrected to the normal conditions in mg/Nm^3, which is calculated using the gas volumetric flow rate corrected to normal conditions (dry, 273K, 101.3 kpa) (table 5).

Table 4 Stack source release parameters

Source	Source type	Height of the Stack (m)	Exit temperature of flue gas (K)	Diameter of the Stack (m)	Exit velocity (m/s)	Flow rate (Nm^3/s)
Stack – 1	Wake-free point source	150	240	6.5	12.5	709.3
Stack – 2	Wake-free point source	180	315	7.5	21.3	2212.4
Stack - 3	Wake-free point source	210	460	7.5	25.7	3411.28

Table 5 Stack Emission Concentrations

Source	Pollutant	Emission rate (gm./s)	Corrected concentration (mg/Nm^3)	Regulated concentration (mg/Nm^3 at stack reference conditions)
Stack -1	SPM	978.6	1370.5	150
	Sulfur dioxide	230.54	325.6	NA
	Nitrogen oxides	430.6	667.4	NA
Stack – 2	SPM	1261.9	570.84	150
	Sulfur dioxide	360.23	162.82	NA
	Nitrogen oxides	223.5	101.2	NA
Stack - 3	SPM	1346.5	394.71	150
	Sulfur dioxide	451.6	132.3	NA
	Nitrogen oxides	137.4	40.23	NA

Table 6.The total emission rates and concentrations from all stacks at the UTCL

Source	Pollutant	Total Emission rate (kg/h)	Emission concentration (kg/Nm3 at stack reference conditions)
Stacks - 1,2,3	SPM	8409.77	2.3347
	SO_2	2234.592	0.621
	NO_X	2911.138	0.808

The total emission rates and concentrations from all stacks at the UTCL are shown in table 6.

Emission Factors

An emission factor is a quantity derived to calculate the emission of a pollutant throughout the process. These factors narrate an average value of available data of acceptable quality, and is generally represented the long-term averages of the source type. The emission factors are used when other information is not available. Emission factors for criteria pollutants of the UTCL are calculated as follows:

Emission factor (EF) for SPM
= ER /Activity…… (2)
(Emission controls 99.5%)
8409.77/369 = 22.790
Annual emission rate (ER annual)
= EF (Activity Annual)…… (3)
Annual emission rate (ER annual)

= 22.790 × 3232440 = 73669.58 Tpy

Emission factor (EF) for SO_2
= ER /Activity….. (4)
=2911.138/369 = 7.88
Annual emission rate (ER annual)
= 7.88 × 3232440 = 25471.56 Tpy
Emission factor (EF) for NO_X
= ER /Activity…..(5)
2234.5932/369 = 6.055
Annual emission rate (ER annual)
= 6.055×3232440 = 1957.08 Tpy

Also, it may be observed that the emission factors calculated are used to quantify the emissions of various industries, which are using the coal, depending on their activity and mode of operation (Technology Transfer Network).

Presentation of Emissions Inventory

Comparison of emission inventory by Supplier's specificationsanddirectmeasurementof total emission rates of various combustion products are presented in Table 7.

Table 7. Comparison of emission inventory by Supplier'sspecifications and direct measurement of total emission rates

Emission product	Emission rate (Supplier's specifications)	Emission rate (Direct measurement)
SPM	----	8409.77kg/h
SO_2	4230 kg/h	2234.592 kg/h
NO_X	2786.1 kg/h	2911.138 kg/h
H_2O	9.232 %	9.43%
O_2	3.837 %	3.5%
GCV	4320 K Cal/kg	4000 kcal/kg

Table 8. Emission rates of the pollutants

Source	Pollutant	Emission rate (gm/s)
Stack – 1	SPM	978.6
	Sulfur dioxide	230.54
	Nitrogen oxides	430.6
Stack -2	SPM	1261.9
	Sulfur dioxide	360.23
	Nitrogen oxides	223.5
Stack -3	SPM	1346.5
	Sulfur dioxide	451.6
	Nitrogen oxides	137.4

The results observed from supplier's specifications and direct measurements are comparatively equal. Here sulfur dioxide and Nitrogen oxides values are little difference due to incomplete combustion of coal. Stack parameters and their emission rates are presented in table 8.

Conclusions

This investigation provided primary information and data required for air pollution modeling, and evidently described the information of site specific situation. Emission rates of criteria pollutants and other combustion products are presented from two methods, Manufacturers' design specifications and direct measurement. Direct measurement is more accurate methodology for the development of emission inventory for any industry.

In this emission inventory presentation the results observed from Manufacturers' design specifications and direct measurementare comparatively equal.At this point Sulfur dioxide and Nitrogen oxides values are small disparity owing to incomplete combustion of coal.

Emission rates provided can be applied for environmental modeling and for environmental impact assessment criteria. Emission factors also calculated for criteria pollutants for future estimations, if emission data is not available for that particular cement industry. Annual emission rates are provided from emission factors and annual activity.

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