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# Measurement of $CO_2$, CO, $SO_2$, and NO emissions from coal-based thermal power plants in India

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**Abstract**

Measurements of $CO_2$ (direct GHG) and CO, $SO_2$, NO (indirect GHGs) were conducted on-line at some of the coal-based thermal power plants in India. The objective of the study was three-fold: to quantify the measured emissions in terms of emission coefficient per kg of coal and per kWh of electricity, to calculate the total possible emission from Indian thermal power plants, and subsequently to compare them with some previous studies. Instrument IMR 2800P Flue Gas Analyzer was used on-line to measure the emission rates of $CO_2$, CO, $SO_2$, and NO at 11 numbers of generating units of different ratings. Certain quality assurance (QA) and quality control (QC) techniques were also adopted to gather the data so as to avoid any ambiguity in subsequent data interpretation. For the betterment of data interpretation, the requisite statistical parameters (standard deviation and arithmetic mean) for the measured emissions have been also calculated. The emission coefficients determined for $CO_2$, CO, $SO_2$, and NO have been compared with their corresponding values as obtained in the studies conducted by other groups. The total emissions of $CO_2$, CO, $SO_2$, and NO calculated on the basis of the emission coefficients for the year 2003–2004 have been found to be 465.667, 1.583, 4.058, and 1.129 Tg, respectively.


*Keywords:* Thermal power plants; On-line measurement; Direct and indirect GHG; Emission coefficient

## 1. Introduction

In relation to preparation of India's National Communication (NATCOM) to the United Nations Framework Convention on Climate Change (UNFCCC) and to measure the amount of the direct ($CO_2$) and indirect (CO, $SO_2$, and NO) GHGs (Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories) from the coal-fed thermal power plants in India, a project work was undertaken. Measurements of these gases were carried out on-line using IMR 2800P Flue Gas Analyzer at 11 numbers of generating units of varying ratings over a period of 2 years during 2003–2004 on different days.

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The installed electricity generation capacity of the different coal-fed units were 60, 67.5, 210, and 250 MW, respectively, and most of the units were performing with a plant-load factor of almost equals to unity except for a particular plant where the plant-load factor varied between 0.667 and 1.00. Since the Indian power grids are well connected, power can be sold to any location in India. With this it has been observed that generations of the plants under observation were almost equal to the rated generation capacity, and this has been reflected in plant-load factor of almost equals to unity in most of the cases. The calculations for the emission coefficients have been made on the actual generations during the time of measurement. The age of the generating units varied from 5 to 20 years.

Studies related to emission measurement and estimations from thermal power plants conducted by different researchers, scientists, and organizations (Mittal and Sharma, 2003b; Jorge et al., 2002; Ryerson et al., 1998; Gillani et al., 1998; Gurjar et al., 2004; Garg et al., 2001; TERI, 2001a; Varshney and Aggarwal, 1992; Chandra and Chandra, 2003; Modeling Anthropogenic Emissions from Energy Activities in India: Generation and Source Characterization) have confirmed the toxic potential of the measured gases particularly with respect to the increasing trend in temperature or in other words global warming and therein lies the importance of carrying out this project work to determine the amount of emissions of these gases particularly for a very fast developing economy like India. The emission coefficients for different gases have been calculated for different category of generating units by applying statistical methods. The figures have been calculated based on repeatedly measured values following IPCC guidelines (Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories). The consistencies of measured values of the generating units were also checked (see Table 1). Certain quality control measures as well as uncertainty reduction methods were adopted during the measurement process, and also during calculations to find out the emission co-efficients. The variations in emission of the different gases for the different units of the thermal power plants have been dealt elaborately with specific and pertinent reasonings in the successive paragraphs of Section 3. The emission co-efficients for different gases were obtained for per kWh of electricity generated and per kg of coal utilized. The emission coefficients have been compared with the values as obtained in the previous studies (Gurjar et al., 2004; Modeling Anthropogenic Emissions from Energy Activities in India: Generation and Source Characterization). Further, the total estimated emission for $CO_2$ has been compared with the study conducted by OSC (Modeling Anthropogenic Emissions from Energy Activities in India: Generation and Source Characterization). This is probably the first communication presented systematically by an Indian group on emissions only from thermal power plants which is based on measurements carried out on-line in a plant following standard experimental guidelines.

Table 1
Consistency check in the measurement process with an interval of about 30 min at a fixed load

| Serial no. | Time of measurement (h) | Measured emission rate at generator unit S4U2 (installed capacity 67.5 MW) | | | |
|---|---|---|---|---|---|
| | | $CO_2$ (%) | CO ($mg\,m^{-3}$) | $SO_2$ ($mg\,m^{-3}$) | NO ($mg\,m^{-3}$) |
| 1 | 12:09 | 12.0 | 40 | 634 | 516 |
| 2 | 12:35 | 12.2 | 30 | 636 | 509 |
| 3 | 13:06 | 12.6 | 40 | 657 | 488 |
| 4 | 13:34 | 12.4 | 40 | 647 | 480 |
| 5 | 14:41 | 12.4 | 40 | 541 | 488 |
| 6 | 15:08 | 12.4 | 40 | 552 | 486 |
| 7 | 15:35 | 12.9 | 40 | 558 | 471 |
| 8 | 16:02 | 12.4 | 40 | 556 | 476 |
| 9 | 16:37 | 13.1 | 40 | 628 | 449 |
| Arithmetic mean[a] | | 12.49 | 40 | 601 | 484.78 |

[a]All the variations are within a range of ±10% of the mean value. Emission figure of CO has been considered as $40\,mg\,m^{-3}$.

## 2. Experimental process

The instrument used for measuring the direct and the indirect GHG emissions was the IMR 2800P Flue Gas Analyzer made by IMR Inc., USA (Operation Manual of IMR 2800P Flue Gas Analyzer). The instrument was provided with necessary pump and an interconnecting flexible hose with fixed thermocouple sensing wire. As soon as the instrument was switched on, self-calibration started automatically. Fresh air was drawn in by the in-built pump in the instrument from the normal atmosphere through the probe. It also purged out any gas/air present inside the instrument and finally