

**SOURCE APPORTIONMENT OF PARTICULATE MATTER  
POLLUTION AROUND A PIT HEAD  
THERMAL POWER STATION**

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**June 2016**



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POLLUTION AROUND A PIT HEAD  
THERMAL POWER STATION**

by

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Department of Civil Engineering

**Thesis**

Submitted in fulfilment of the requirements for the degree of

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to the



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June 2016

## **CERTIFICATE**

This is to certify that the thesis titled “**Source apportionment of particulate matter pollution around a pit head thermal power station**” being submitted by **K. V. George**, to the Indian Institute of Technology, Delhi, for the award of the degree of **Doctor of Philosophy** in Civil Engineering is a bonafide record of the research work carried out by him under my supervision and guidance. He has fulfilled the requirements for the submission of this thesis, which, to the best of my knowledge, has reached the requisite standard.

The results contained in this thesis have not been submitted in part or full to any other University or Institute for the award of any degree or diploma.

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## ABSTRACT

Coal based Thermal Power Stations (CTPS) also called 'pit head' units if located near coal mining area occasionally face the criticism of being major air polluter due to its visible dust emission from tall stacks. A counter argument usually put forth by power plant operator is that mining activity being a surface level activity generates dust that disperse at human exposure level causes more air pollution in the vicinity of power plant unlike the elevated ducted emission, which travels far away under the impact of wind. This study aims to analyze the sources of air pollution in a region comprising coal mining, and power generation and attribute its contribution to the ambient air pollution.

Chandrapur district in Maharashtra, India bestowed with large coal reserve of different grades feeds a 2340 MW power station is chosen for the study. Coal extraction, its loading, transportation, local trading, and combustion at domestic and industrial level releases large amount of pollutant at different temporal and special scales both at ground level and at elevated level. Considering the diverse nature of air pollution emission, it is challenging to identify the polluter in a pit head Thermal Power Station (TPS).

Field reconnaissance survey was carried out to identify the possible sources of air pollution in the region. Based on visually identified sources and activities, the Chandrapur area is divided into two regions: one is 'Padmapur' which is having coal mine and the TPS, and the other is 'Ghugus', 20 km away from Padmapur towards west having only coal mining, trading, transport and related activity.

Gaseous criteria pollutant viz. SO<sub>2</sub>, NO<sub>x</sub> is excluded here due to its co-linearity among most of the source emissions. Due to resource constraint for the field intensive research work, Source Apportionment (SA) is restricted to Particulate Matter (PM) only. Samples of PM from emission sources and ambient air were collected using non-viable, Eight Stage Cascade Impactor (8-SCI) and analysed using SEM-EDAX.

Field observation and elemental data analysis revealed that from the viewpoint of source apportionment, the study area is different from any other earlier reported cases due to two reasons. Firstly, most of the sources are mixture of only two entities; coal (high carbon content) and native soil (high silicon and aluminium) and secondly, the receptors are strongly dominated by local sources (coal and soil) due to geographic proximity unlike an urban area where distant sources have equal chance to contribute to the ambient receptors. All sources and receptor PM have three common elements i.e. carbon, silicon and aluminium in different proportions thereby not letting identify any specific marker species for source attribution.

Site-specific source profiles (chemical composition) are generated using elements and it is found that they are not distinctly different instead; they differ due to 'gradually varying' carbon, silicon and aluminium content. The source apportionment analysis is carried out using chemical mass balance (CMB) requiring selection of appropriate source profile and chemical species for fitting. Since the source profiles differ due to marginal variation of species content, selection of sources for fitting becomes a tedious task. This problem is solved by first performing cluster analysis of source profiles, which groups and separates source data in different clusters using distance matrix. Source profile selection becomes easy in subsequent CMB analysis. Seventy five percent of the chemically analysed samples showed presence of more than 45% carbon and remaining twenty five percent samples showed presence of more than 30% carbon. None of the ambient air PM sample showed presence of fly ash signature indicating that emission from power plant stack is not contributing to the ambient air of the study region.

Source dispersion modelling using CALPUFF model is carried out in 48 km x 48 km domain, with MM5 generated meteorological data in 4 km x 4 km sub grid, for one-year. Source dispersion simulation is carried out for emissions from mine area, coal loading at railway yard, loading and unloading at coal trading centre, road dust re-suspension and stacks of TPS and small scale industries (steel, power). It is found that for most of the time the emission puffs from elevated sources of TPS travels outside the study area. The emission from small scale industries do not contribute much at ground level. The emission from area sources and road dust re-suspension at ground level contributes significantly to the ambient air quality.

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## ABBREVIATIONS

4-CSS	Four Channel Speciation Sampler
8-SCI	Eight Stage Cascade Impactor
AMS	American Meteorological Society
AOD	Aerosol Optical Depth
ARAI	Automotive Research Association of India
BAM	Beta Attenuation Monitor
BCCL	Bharat Coking Coal Limited
CALPUFF	California Puff Model
CBL	Convective Boundary Layer
CEPI	Comprehensive Environmental Pollution Index
CIL	Coal India Limited
CMB	Chemical Mass Balance
CMFRI	Central Mining and Fuel Research Institute
CPCB	Central Pollution Control Board
CSIR	Council of Scientific and Industrial Research
CSTPS	Chandrapur Super Thermal Power Station
CTPS	Coal based Thermal Power Station
DGMS	Director General of Mine Safety
DRI	Desert Research Institute
ECL	Eastern Coalfield Limited
EC-OC	Elemental Carbon and Organic Carbon
EF	Enrichment Factor
EIA	Environmental Impact Assessment
EOS	Earth Observing System
EPA	Environmental Protection Agency
ETA	Eastern Technical Associates
FA	Factor Analysis
FDM	Fugitive Dust Model
FRM	Federal Reference Method
GFF	Glass Fiber Filter
GLC	Ground Level Concentration
GSD	Geometric Standard Deviation
HVS	High Volume Sampler
IIT	Indian Institute of Technology
IOCL	Indian Oil Corporation Limited
ISCST3	Industrial Source Complex Short Term 3
ISM	Indian School of Mines
LLD	Log Logistic Distribution Model
Lpm	Liter per minute
MAHAGENCO	Maharashtra State Power Generation Company

MISR	Multiangle Imaging Spectro Radiometer
MM5	Mesoscale Model of 5th Generation
MPCB	Maharashtra pollution Control Board
NAAQS	National Ambient Air Quality Standard
NAMP	National Air Monitoring Program
NASA	National Atmospheric Space Administration
NCDC	National Climatic Data Center's
NCR	National Capital Region
NEERI	National Environmental Engineering Research Institute
NWS	National Weather Station
OB	Over Burden
OCM	Open Cast Mines
OVP	Old View Point
PCA	Principal Component Analysis
PM	Particulate Matter
PMF	Positive Matrix Factorization
PSI	Pollution Standard Index
PTFE	Poly Tetra Fluoro Ethylene
RA	Risk Assessment
RDS	Respirable Dust Sampler
RM	Receptor Modeling
RPM	Respirable Particulate Matter
SA	Source Apportionment
SBL	Stable Boundary Layer
SCE	Source Contribution Estimate
SECL	South Eastern Coalfield Limited
SEM	Scanning Electron Microscope
SEM	Scanning Electron Microscope
SOA	Secondary Organic Aerosol
SPM	Suspended Particulate Matter
SSI	Small Scale Industry
TATR	Tadoba Andhari Tiger Reserve
TCL	Tata Chemical Limited
TEOM	Tapered Element Oscillating Microbalance
TERI	The Energy Research Institute
TPS	Thermal Power Station
TSP	Total Suspended Particle
TSPM	Total Suspended Particulate Matter
TTN	Technology Transfer Network
WCL	Western Coalfields Limited