

Ozone Pollution in India Due to Power Plant Emissions



Engineering

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ABSTRACT

Coal is the primary fuel for electricity generation in India and its usage is continuously increasing to meet the energy demands of the country. This paper presents emissions from thermal power plants in India and contribution of power plant emissions in the formation of ground level ozone which shows considerable impact on environment. The emission estimates are based on a model in which the mass emission factors are theoretically calculated using the basic principles of combustion and operating conditions. Future emission scenarios for the period up to 2020-21 are generated based on the estimates of the nine years from 2001-02 to 2009-10. Power plants in India use different qualities of coal, different combustion technologies and operating conditions. As a result, these plants have differences in achieved efficiencies (coal usage per unit of electricity). The estimates show region wise differences in total emissions as well as differences in emissions per unit of electricity. Computed estimates show the total CO₂ emissions from thermal power plants have increased from 323474.85 Gg for the year 2001-02 to 498655.78 Gg in 2009-10. SO₂ emissions increased from 2519.93 Gg in 2001-02 to 3840.44 Gg in 2009-10, while NO emissions increased from 1502.07 Gg to 2314.95 Gg during this period. The emissions per unit of electricity are estimated to be in the range of 0.91 to 0.95 kg/kWh for CO₂, 6.94 to 7.20 g/kWh for SO₂, and 4.22 to 4.38 g/kWh for NO during the period 2001-02 to 2009-10. The future emission scenario, based on the projected coal consumption in Indian thermal power plants by Planning Commission of India under 'Business-as Usual (BAU)' and "Best case Scenario (BCS)" show the emission in the range of 714976 to 914680 Gg CO₂, 4734 to 6051 Gg SO₂ and 366 to 469 Gg NO in the year 2020-21. Increase in coal use in electricity generation by thermal power plants can significantly increase the emissions of greenhouse and polluting gases.

1. INTRODUCTION

Emissions⁴ of greenhouse gases and other pollutants are increasing in India with the increasing demand for electricity. The aspiration for rapid economic growth leading to rapid industrialization coupled with accelerated urbanization¹⁰ and mechanization of agriculture has been responsible for this increasing demand of electricity ever since the independence. The electricity consumption grew from 375.39 (billion kWh) in 2000 to 600.65 (billion kWh) in 2008 at an annual growth rate of 6.67% , while the electric power generation grew from 529.12 billion kWh in 2000 to 835.27 billion kWh at an annual growth rate of 5.78% www.eia.doe.gov, 2010). Large difference between electric power generation and consumption are due to transmission and distribution losses. In India, the losses are extremely high and vary between 30 to 45%.

To ensure 'Power on Demand'², India has envisioned an additional generating capacity of 100,000 MW by the year 2012. It is estimated that electricity demand outstrips supply by 7-11%. With India's population of more than a billion that is growing at an annual rate of about 2% www.powermin.nic.in - Annual Report⁸ 2008-09) electric power availability is approximately 11.1 % short of demand with peak load shortages of 11.9 %, whereas in 2000-01, power capacity was 7.8 % short of demand with peak load shortage of 13%. Percentage of the electric energy shortage and peak shortage from the period 2000-01 to 2008-09, the gap between demand and supply of the electricity may rise further.

Coal is the favorite fuel for the electricity generation in countries like India and China. Abundant supply of coal locally and sustained high prices for imported natural gas and oil make coal-fired³ generation of electricity more attractive economically. Coal is approximately 90% of the total fuel mix for electricity generation. Coal and lignite based power plants have approximately 54.42% of the total electric power generation capacity in India. However, relatively lower calorific value, coupled with high ash content and inefficient combustion technologies aggravates emission of greenhouse gases⁹ and other pollutants from India's coal and lignite based thermal power plants.

3. PRECURSORS OF OZONE FROM POWER PLANTS

Main emissions from coal fired and lignite based thermal power

plants¹¹ are CO₂, NO_x, SO_x, CO, VOC_s and air-borne inorganic particles such as fly ash, carbonaceous material (soot), suspended particulate matter (SPM), and other trace gas species. Thermal power plants, using about 70% of total coal in India (Garg et al., 2002), are among the Large Point Sources (LPS) having significant contribution (47% each for CO₂ and SO₂) in the total LPS emissions in India.

Ozone (O₃) is a secondary pollutant formed by atmospheric reactions involving two classes of precursor compounds¹, volatile organic compounds (VOC_s) and nitrogen oxides (NO_x)¹². Carbon monoxide also contributes to O₃ formation. The formation of O₃ and associated compounds is a complex, nonlinear function of many factors, including the intensity and spectral distribution of sunlight; atmospheric mixing and other atmospheric processes; and the concentrations of the precursors in ambient air. The main source of the above precursor compounds in India is vehicular pollution and power plants.

Troposphere or "surface-level" ozone is one of six major air pollutants regulated by National Ambient Air Quality Standards (NAAQS) under the U.S. Clean Air Act.

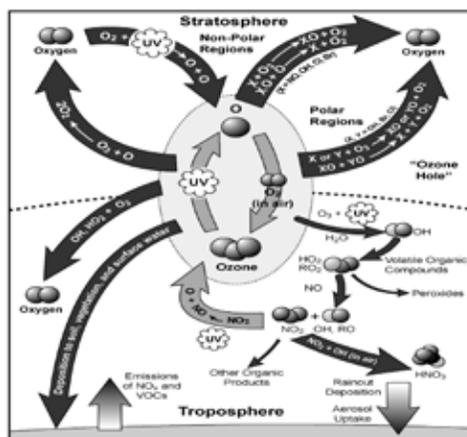


Fig.1 : CHEMISTRY OF OZONE

4. OZONE CONCENTRATION IN INDIA

Ozone has a strong relationship with biomass burning, traditionally seen over eastern parts of the subcontinent extending into that East Asia. This area is also a thickly vegetated region releasing organic compounds that participate in atmospheric photochemistry in which ozone has a significant role to play. Thus the anthropogenic emission defines the residence times of various GHGs of biogenic origin via the ozone link in this region. Total ozone and Umkehr observation by Dobson Ozone spectrophotometer are taken daily basis from 4 stations viz. Delhi, Varanasi, Pune and Srinagar. At Delhi, Kodaikanal and Maitri (Antarctica) ozone is monitored with Brewer Spectrophotometer, which has an additional facility to measure NO₂, SO₂ and UV-B radiation also. Vertical distribution of ozone is measured by balloon-borne ozonesonde (IMD-made) fortnightly frequency at Delhi, Pune, Thiruvananthapuram and Maitri (Antarctica). Surface ozone measurement is taken at 6 stations viz. New Delhi, Nagpur, Pune, Kodaikanal, Thiruvananthapuram and Maitri (Antarctica). Monitoring is being augmented by establishing stations in NE India and A&N Islands. Important results from the Ozone Programme spanning over more than 50 years are as follow:

- Ozone data of Maitri (Antarctica) has also confirmed occurrence of ozone hole during spring months over Antarctica

(Peshin, 2006).

- Analysis of the data available so far does not establish any clear ozone trends in the total ozone over India. However, increasing trend in tropospheric and decreasing trend in stratospheric ozone have been observed.
- From the equator to about 20°N, the tropospheric ozone concentration remains practically the same throughout the year.
- The maximum ozone concentration of the order of 150µmb occurs at a height of 26-27 Km over Thiruvananthapuram, 25-26 Km over Pune and 23-25 Km over New Delhi. Double maxima appears over New Delhi during winter and spring.

5. CONCLUSION

Ground level ozone is the most important index substance of photochemical smog. Photochemical smog is now observed in many urban and industrial centers around the world and it has become a common phenomenon in many large cities. Ozone is a most harmful pollutant for humans; in addition it plays an important role in damaging vegetation and materials. Therefore it becomes important to measure the ground level ozone at different locations of urban areas especially in the tropical countries like India where the power plant emissions are high.

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