MAINS Impact- 2025 – 19/11/2024

THERMAL POWER PLANTS AND POLLUTION

SYLLABUS:

GS 3 > Environment >> Pollution

REFERENCE NEWS:

Delhi's Air Quality Index (AQI) reading soared to an alarming 481, placing several areas in the 'severe' category of the index. A report by think tank Centre for Research on Energy and Clean Air (CREA) has turned the spotlight on thermal power plants as a dominant, year-round source of sulphur dioxide (SO□) emissions. These plants emit SO□ at levels 240 times greater than stubble burning, a seasonal contributor to air pollution that often garners significant attention, the paper highlighted.

THERMAL POWER PLANTS IN INDIA:

Thermal power plants or thermal power stations are power stations that generate electricity from heat. Thermal power plants use different sources of energy to produce heat, including coal, oil, natural gas, and geothermal sources.

- As of 2024, thermal power plants account for around **60-65% of India's total electricity generation capacity**. This makes thermal energy the most significant contributor to the country's energy mix.
- According to the Central Electricity Authority (CEA), India's total installed electricity generation capacity is approximately 425 GW, with thermal power contributing about 250 GW.
- **Coal-Based Plants** are the most common and contribute to over 80% of the thermal power capacity. Coal is an abundant resource in India, and the majority of plants utilize domestic coal as it is the 2nd largest coal producer in the world.
- Thermal power plants are significant employers, as they constitute over 70 per cent of India's annual electricity generation and directly **employ 3.2–4 lakh individuals** across the country (CEA 2021; CEA 2024).

CONTRIBUTION OF THERMAL POWER PLANTS TO POLLUTION IN INDIA:

AIR POLLUTION:

- Thermal power plants are the largest industrial contributors to air pollution in India, emitting large quantities of particulate matter (PM), sulphur dioxide (SO□), nitrogen oxides (NOx), and carbon dioxide (CO□).

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- In 2021, thermal power plants were responsible for approximately 45% of India's total CO□ emissions, contributing to the country's status as the third-largest emitter of greenhouse gases globally.

- **Particulate Matter (PM2.5 and PM10)**: Coal-based power plants emit fine particulate matter (PM2.5), which can penetrate deep into the lungs, causing respiratory and cardiovascular diseases.

    - A study by the Centre for Science and Environment (CSE) highlighted that PM emissions from coal-fired plants contribute to over 80% of PM2.5 pollution in Delhi, especially during the winter months.

- **Sulphur Dioxide (SO□)**: In 2022, India was the world's top emitter of SO□, contributing to over 20% of global human-caused emissions, primarily because of its dependence on coal for power production.

    - While stubble burning accounts for 17.8 kilotonnes of SO□ emissions annually, thermal power plants emit over 240 times more, found the analysis. SO□ is a precursor to fine particulate matter (PM2.5), a significant pollutant that worsens respiratory and cardiovascular diseases. It also leads to acid rain, causing widespread ecological harm.

- **Nitrogen Oxides (NOx)**: NOx emissions contribute to the formation of ground-level ozone, which can cause respiratory problems, and smog, impacting air quality.

    - In 2020, a report by the International Energy Agency (IEA) noted that India's coal-based power sector accounted for nearly 30% of the country's NOx emissions.

GREENHOUSE GAS EMISSIONS (GHG):

- **CO□ Emissions**: Thermal power plants are the largest source of CO□ emissions in India, a key driver of global warming and climate change.

    - In 2021, India's coal-fired power plants emitted about 1.1 billion tonnes of CO□, accounting for 50-60% of the country's total CO□ emissions. The Korba Super Theral Power Plant in Chhattisgarh is one of the highest CO□ emitters, given its large installed capacity and reliance on domestic coal.

- **Climate Impact**: The heavy reliance on coal for electricity generation has been a major obstacle in India's efforts to meet its climate commitments, including the Nationally Determined Contributions (NDCs) under the Paris Agreement.

WATER POLLUTION:

- **Thermal Power and Water Contamination**: Thermal power plants, particularly those based on coal, use large quantities of water for cooling, leading to thermal pollution in nearby water bodies. Discharges from plants often contain heavy metals like mercury, arsenic, and lead, polluting local water sources.

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- The Tirora Thermal Power Plant in Maharashtra has faced criticism for discharging hot water into nearby rivers, causing a significant rise in water temperatures and impacting aquatic life.

- **Mercury Pollution**: Coal-fired power plants are the largest source of mercury emissions in India. Mercury from coal combustion settles in water bodies, contaminating fish and posing risks to human health.

  - According to a report by the Mercury in India's Power Sector (2018), Indian coal-fired plants emit approximately 71 tonnes of mercury annually.

- **Ash Ponds and Groundwater Contamination**: Many thermal power plants dispose of fly ash, a byproduct of coal combustion, in ash ponds. These ash ponds can leach toxic substances into the soil and groundwater, impacting drinking water sources.

  - **Example**: The Fly Ash Dyke Failure incident at the NTPC Vindhyachal Power Plant in Madhya Pradesh (2019) led to the spillage of toxic ash slurry, contaminating agricultural lands and local water bodies.

LAND POLLUTION

- **Fly Ash Disposal**: Coal-based thermal power plants generate millions of tonnes of fly ash annually. Improper disposal of fly ash has led to severe land and soil pollution, affecting agriculture and local ecosystems.

  - India generates over 200 million tonnes of fly ash annually, with about 30-40% of it not being utilized, leading to the creation of massive ash ponds.

  - The Badarpur Thermal Power Station in Delhi, which has since been shut down, was a significant source of fly ash pollution, with fly ash dispersal affecting nearby residential areas.

- **Land Degradation**: Open-pit coal mining, which supplies coal to thermal power plants, also leads to land degradation and deforestation. The loss of green cover contributes to soil erosion and loss of biodiversity.

  - The Jharia Coalfield in Jharkhand, known for its extensive coal mining to supply power plants, has experienced severe land degradation and underground coal fires that have been burning for decades.

IMPACT OF SUCH POLLUTION:

Economic Impact

- **Healthcare Costs**: Pollution from thermal power plants, especially air pollutants like particulate matter (PM), sulphur dioxide (SO□), and nitrogen oxides (NOx), has a direct impact on public health. Increased respiratory, cardiovascular, and other pollution-related illnesses lead to higher healthcare costs.

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- **Economic Burden**: According to the Lancet Commission on Pollution and Health (2022), air pollution in India results in healthcare costs estimated at about 1-3% of GDP annually, with thermal power plants being a major contributor.

- **Agricultural Impact**: Thermal power plants contribute to acid rain through SO□ and NOx emissions, which can damage crops, reduce soil fertility, and lower agricultural yields. This has a direct economic impact on rural communities dependent on farming.
    - In regions like Singrauli and Korba, heavy air pollution from power plants has been linked to declining agricultural productivity and crop damage.
- **Costs of Environmental Degradation**: Pollution from thermal power plants leads to environmental degradation, including contaminated water bodies and damaged ecosystems.
    - **Fly Ash Management**: Improper disposal of fly ash, a byproduct of coal combustion, has economic costs associated with managing ash ponds and preventing soil and groundwater contamination.
- **Infrastructure and Compliance Costs**: The need to retrofit existing thermal power plants with pollution control technologies, such as Flue Gas Desulfurization (FGD) units and Electrostatic Precipitators (ESP), imposes substantial costs on the power sector.

Social Impact

- **Impact on Rural Communities**: Pollution can lead to the contamination of local water sources, soil degradation, and loss of agricultural land, disrupting the livelihoods of farmers and rural populations.
    - In areas like Talcher in Odisha, heavy reliance on coal-based power plants has led to significant environmental degradation, impacting the health and livelihoods of local communities who depend on agriculture.
- **Displacement and Loss of Livelihoods**: The establishment of thermal power plants often involves land acquisition, which can displace local communities and lead to the loss of livelihoods, particularly for indigenous and marginalized populations.
    - Large-scale coal mining to supply power plants has led to the displacement of tribal communities in regions like Jharkhand, affecting their socio-cultural ties to the land.
- **Social Inequality**: Lower-income and marginalized communities often reside closer to power plants, bearing the brunt of pollution-related health impacts due to their limited access to healthcare and cleaner environments.
    - **Environmental Justice**: A lack of stringent regulation enforcement in poorer regions has led to disparities in pollution exposure, raising concerns about environmental justice.

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- **Impact on Water Resources**: Thermal power plants are water-intensive, using large quantities for cooling purposes. This can lead to local water scarcity, impacting agriculture, drinking water availability, and overall quality of life.
    - In states like Maharashtra, during periods of drought, power plants have been prioritized for water supply over local communities, leading to social unrest and water conflicts.
- **Urban Pollution and Quality of Life**: In urban areas, thermal power plants located near cities contribute significantly to smog and poor air quality. This affects the daily lives of millions, leading to restricted outdoor activities, increased allergies, and respiratory problems.
    - The now-closed Badarpur Thermal Power Plant in Delhi was identified as a major source of winter smog, contributing to the city's severe air pollution problem.

WAY FORWARD:

- **Stricter Enforcement of Emission Standards**: The European Union's Industrial Emissions Directive (IED) mandates stricter emission limits for pollutants from power plants. India can take cues from Europe by implementing stringent standards and providing clear timelines for compliance.
- **Upgrading Pollution Monitoring Systems**: In India, the Ministry of Environment, Forest and Climate Change (MoEFCC) has mandated the installation of Continuous Emission Monitoring Systems (CEMS) in major industrial units, but effective enforcement remains a challenge.
- **Adoption of Supercritical and Ultra-Supercritical Technology**: Transitioning from sub-critical to supercritical and ultra-supercritical technology can significantly reduce emissions and improve efficiency.
    - **NTPC's Supercritical Plants**: NTPC, India's largest power producer, has successfully implemented supercritical technology in several plants, such as the Mouda Super Thermal Power Station in Maharashtra, leading to better efficiency and lower emissions.
- **Installation of Pollution Control Equipment**: **Installing Flue Gas Desulfurization** (FGD) units, Electrostatic Precipitators (ESP), and Selective Catalytic Reduction (SCR) systems can help control emissions of SO□, particulate matter, and NOx.
    - The Dadri Power Plant in Uttar Pradesh, managed by NTPC, installed FGD units, leading to a substantial reduction in sulphur emissions.
- **Fly Ash Management**: Promoting the utilization of fly ash in construction, road building, and cement production can help reduce the burden on ash ponds and prevent soil and water contamination.

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- **Use of Fly Ash in Construction**: The Delhi Metro project extensively used fly ash bricks, demonstrating how industrial waste can be repurposed for sustainable construction.

- **Gradual Transition to Renewable Energy**: A phased reduction in the dependence on coal-based thermal power can be achieved by increasing the share of solar, wind, hydro, and biomass energy in the electricity mix.
    - **India's Renewable Energy Push**: India has set an ambitious target of 500 GW of renewable energy capacity by 2030. The success of the Gujarat Solar Park and the Pavagada Solar Park in Karnataka highlights the feasibility of large-scale solar projects as alternatives to coal-based power.
- **Co-firing Biomass with Coal**: Encouraging thermal power plants to use biomass as a partial substitute for coal (co-firing) can reduce greenhouse gas emissions and provide an avenue for waste management.
    - The Rajpura Thermal Power Plant in Punjab has implemented biomass co-firing, using paddy straw as a substitute for coal. This helps tackle both pollution from stubble burning and emissions from thermal power generation.
- **Carbon Pricing and Emission Trading Schemes**: Introducing carbon pricing or an Emission Trading Scheme (ETS) can provide economic incentives for power plants to reduce emissions.
    - **China's Emission Trading System**: China has implemented a national carbon market that covers its power sector, including coal-based thermal plants. India can study China's model to design an effective ETS for reducing emissions.
- **Financial Incentives for Clean Technology**: Providing subsidies, tax benefits, and low-interest loans for retrofitting existing plants with pollution control technologies can encourage faster adoption.
    - The Indian government has introduced incentives under schemes like the Perform, Achieve, and Trade (PAT) mechanism to improve energy efficiency in thermal power plants.
- **Promotion of Water-Efficient Cooling Technologies**: Encouraging thermal power plants to adopt dry cooling systems or hybrid cooling systems can reduce water usage. Water audits should be mandatory to monitor and minimize water consumption.
    - The Dadri Thermal Power Station implemented a water recycling and reuse project, reducing its freshwater consumption by treating wastewater for cooling purposes.
- **Zero Liquid Discharge (ZLD) Systems**: Implementing ZLD systems to ensure that no industrial effluent is discharged into local water bodies can protect water resources from contamination.

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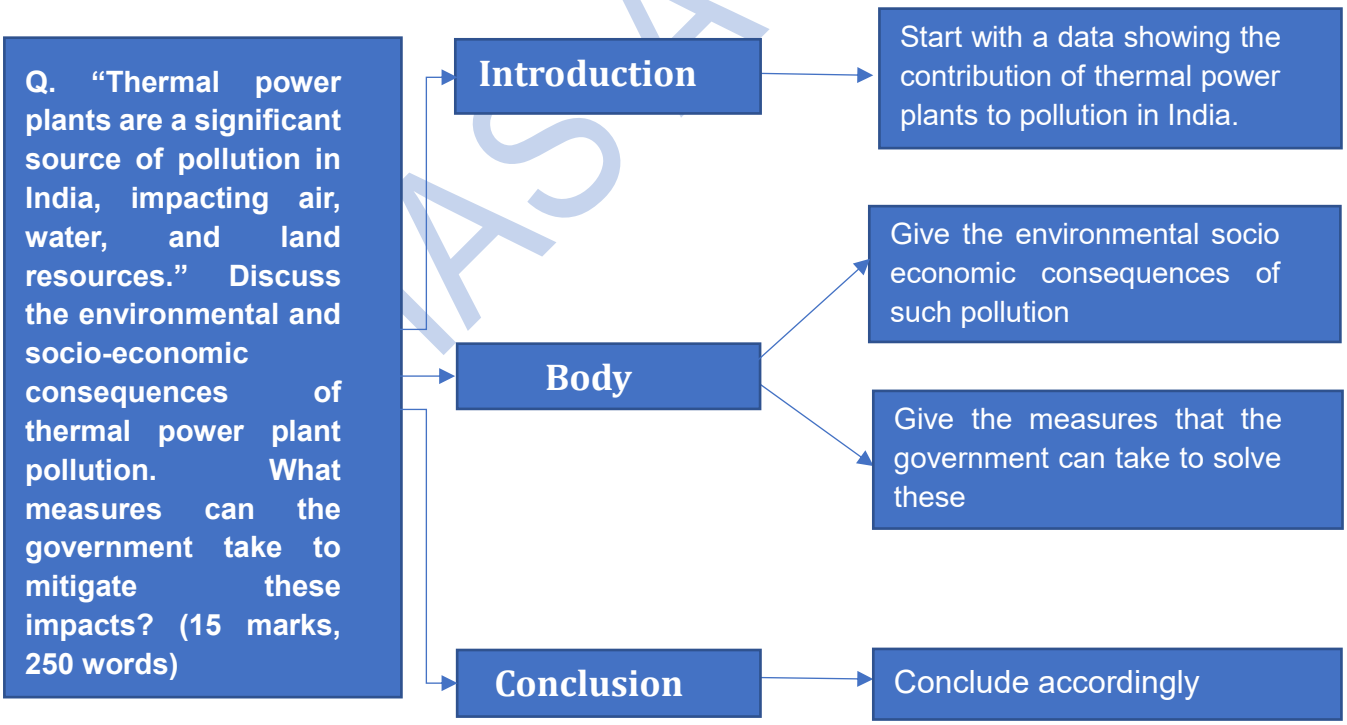
- **NTPC's Effluent Management**: NTPC's Simhadri Power Plant in Andhra Pradesh has adopted a ZLD system to ensure that no wastewater is released into the environment, setting a benchmark for other plants.

- **Engagement with Local Communities**: **Singrauli's Citizen Science Initiative** of Singrauli region is a community-based environmental monitoring initiatives have empowered local residents to track pollution levels and advocate for stricter regulations.
- **Health Impact Assessments (HIA)**: In the Chandrapur District of Maharashtra, NGOs have conducted HIAs to document the health impacts of pollution from nearby power plants, leading to greater public awareness and demands for action.
- **Investment in Clean Coal Technology**: Investing in research and development for advanced clean coal technologies, such as Integrated Gasification Combined Cycle (IGCC) and Carbon Capture and Storage (CCS), can help reduce the carbon footprint of coal-based plants.

PRACTICE QUESTION:

Q. "Thermal power plants are a significant source of pollution in India, impacting air, water, and land resources." Discuss the environmental and socio-economic consequences of thermal power plant pollution. What measures can the government take to mitigate these impacts? (15 marks, 250 words)

APPROACH:



MODEL ANSWER:

Thermal power plants, particularly those using coal, are a dominant source of electricity in India, contributing to around 60-65% of the nation's energy needs. However, they are also one of the largest sources of pollution, impacting the environment and society. In 2022, India

was the world's top emitter of SO□, contributing to over 20% of global human-caused emissions, primarily because of its dependence on coal for power production.

ENVIRONMENTAL AND SOCIO-ECONOMIC CONSEQUENCES:

1. **Air Pollution**: In 2021, coal-based thermal power plants were responsible for 45% of India's CO□ emissions, making the country the third-largest greenhouse gas emitter globally.
2. **Water Pollution**: The Tirora Thermal Power Plant in Maharashtra discharged hot water into nearby rivers, affecting aquatic life. Indian coal-fired plants emit about 71 tonnes of mercury annually, which settles in water bodies, posing risks to health
3. **Land Pollution**: The Badarpur Thermal Power Station in Delhi, now shut down, was a significant source of fly ash pollution, affecting nearby residential areas. In Jharkhand, coal mining for power plants has led to severe land degradation and underground coal fires
4. **Socio-economic Consequences:**
   - **Healthcare Costs**: According to the Lancet Commission on Pollution and Health (2022), air pollution in India results in healthcare costs estimated at about 1-3% of GDP annually, with thermal power plants being a major contributor.
   - **Costs of Environmental Degradation**: Pollution from thermal power plants leads to environmental degradation, including contaminated water bodies and damaged ecosystems.
   - **Infrastructure and Compliance Costs**: The need to retrofit existing thermal power plants with pollution control technologies, such as Flue Gas Desulfurization (FGD) units and Electrostatic Precipitators (ESP), imposes substantial costs on the power sector.
   - **Impact on Rural Communities**: In areas like Talcher in Odisha, heavy reliance on coal-based power plants has led to significant environmental degradation, impacting the health and livelihoods of local communities who depend on agriculture.
   - **Displacement and Loss of Livelihoods**: The establishment of thermal power plants often involves land acquisition, which can displace local communities and lead to the loss of livelihoods, particularly for indigenous and marginalized populations.
   - **Social Inequality**: Lower-income and marginalized communities often reside closer to power plants, bearing the brunt of pollution-related health impacts due to their limited access to healthcare and cleaner environments.
   - **Impact on Water Resources**: In states like Maharashtra, during periods of drought, power plants have been prioritized for water supply over local communities, leading to social unrest and water conflicts.

MEASURES TO MITIGATE IMPACTS

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- **Stricter Emission Standards**: Enforcing stringent emission limits for SO□, NOx, and PM. Adoption of European-style Industrial Emissions Directives can guide compliance. India's installation of Continuous Emission Monitoring Systems (CEMS) can be expanded to cover all major plants
- **Supercritical and Ultra-Supercritical Technology**: Transitioning to more efficient and less polluting technologies can reduce emissions. The NTPC's Supercritical Plants like the Mouda Super Thermal Power Station in Maharashtra have improved efficiency and lowered emissions
- **Fly Ash Utilization**: Promoting the use of fly ash in construction and infrastructure projects to prevent land pollution. The Delhi Metro project utilized fly ash bricks, showcasing a sustainable way to handle industrial waste
- **Water Conservation Measures**: Implementing water-efficient cooling technologies and Zero Liquid Discharge (ZLD) systems. The Dadri Thermal Power Station has reduced water consumption by recycling wastewater for cooling
- **Transition to Renewable Energy**: A phased increase in the share of renewables like solar, wind, and biomass to reduce dependence on coal. India's target of 500 GW of renewable capacity by 2030, with successful projects like the Gujarat Solar Park and the Pavagada Solar Park
- **Public Awareness and Community Engagement**: Engaging local communities in monitoring pollution and enforcing accountability. In Singrauli, citizen science initiatives have empowered locals to advocate for stricter regulations

Thermal power plants are indispensable to India's energy security but have a significant environmental footprint. Addressing the pollution from these plants requires a multi-faceted strategy involving regulatory enforcement, technological upgrades, community involvement, and a shift towards renewable energy. A balanced approach is needed to ensure sustainable development while maintaining energy security.

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