A CASE STUDY ON INDUSTRIAL WASTE MANAGEMENT PROTOCOLS: ANALYZING THERMAL POWER OPERATIONS AND SUSTAINABILITY AT ADANI POWER, TIRORA

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Abstract :

This research paper is a detailed case study looking at how Adani Power Maharashtra Limited in Tirora, Gondia district, manages its industrial waste. We spent two months on-site inspecting the plant and auditing its operations. Our goal was to see how well this 3300 MW supercritical coal-fired power plant follows environmental laws, handles solid waste, controls air pollution, recycles water, and supports the circular economy. We also looked at how its modern design helps save fuel from the very start.

Our findings show that, the facility successfully uses multi-field electrostatic precipitators, dry ash handling systems; sea-water based flue gas desulfurization (FGD) and advanced treatment plants for wastewater and sewage. These systems work together to protect the local air, lower pollution and safely recover useful resources. Because of this technology, the plant keeps its dust and sulfur dioxide emissions well below strict national limits which is very important. The plant uses airtight pipes to move fly ash and water systems to clear out bottom ash. It reuses cleaned wastewater to spray down dust, cool hot ash, refill cooling towers and grow large green belts. This green space helps capture local carbon emissions and moves the plant closer to its goal of releasing zero dirty liquid into the environment. Furthermore, the plant's Ash Utilization Promotion and Research Park (Ash Park) helps turn industrial waste into valuable items like cement mixes, road beds and bricks. Overall, the Adani Power Plant, Tirora provides a highly practical model for running a sustainable power plant. However, moving ash over long distances is still the challenge to them for which they are paying lot. Also, finding nearby buyers are still tough challenges. Apart from these few drawbacks, the waste management strategy of Adani power plant, Tirora can serve as an excellent blueprint for similar power plants around the world.

Keywords : Thermal Power, Waste Management, Fly Ash Utilization, Circular Economy, Flue Gas Desulfurization (FGD), Supercritical Technology, Industrial Sustainability.

Introduction :

Thermal power plants are the bedrock of India's power system, generating roughly 75% of the country's electricity [1-5]. Even though they are essential for meeting our energy needs, burning coal creates massive amounts of solid waste and dirty water. If we want to keep producing electricity without destroying nature, plants must follow strict rules to cut down on waste and reuse resources wherever possible.

This study checks the waste management practices at the Adani Power Maharashtra Limited (APML) plant in Tirora, which is in the Gondia district of Maharashtra. This plant is quite large, producing 3,300 MW of power across five 660 MW units using modern supercritical technology. We conducted 2 months of field study at the site to map out exactly how things work. Specifically, we looked at:

- How solid waste (like fly ash and bottom ash) is sorted?
- How the plant cleans its air emissions and wastewater?
- How local businesses reuse these industrial by-products to build eco-friendly materials?

Literature Review :

In India, the rules for running thermal power plants come mostly from the Ministry of Environment, Forest and Climate Change (MoEF & CC) and the Central Pollution Control Board (CPCB). For example, the government's Fly Ash Notification states that plants must work toward reusing 100% of their ash. This rule helps stop old ash dumps from taking up and ruining good land [6].

Past studies institutional reports have pointed out a lot of environmental problems with old-fashioned wet slurry systems, which mix ash with lots of water [7]. These wet systems can leak heavy metals into underground drinking water, and when the weather gets dry and windy, the ash blows around as dust. Because of this, modern research strongly suggests switching to closed-loop Dry Ash Handling Systems (DAHS) [8]. These dry systems last longer, make transport easier, and save a massive amount of fresh water. Today, experts focused on the circular economy emphasize turning industrial waste, like fly ash and Flue Gas Desulfurization (FGD) gypsum, into useful supplies for the construction industry [9].

Methodology :

For this study, we spent two months on-site looking directly at how the plant operates. We divided our research work into three clear phases :

- **Phase I: Planning and Review :** Before visiting the plant, we collected and analyzed background data. We looked at compliance rules from the CPCB, regional directives from the Maharashtra Pollution Control Board (MPCB), and the company's own sustainability reports.
- **Phase II: Field Inspection and Data Collection :** We went inside the 3,300 MW facilities to see the machinery firsthand. We gathered technical data and checked several systems, including:
    - The dry evacuation setups inside the Electrostatic Precipitators (ESP).
    - The water-filled bunkers used for cooling bottom ash.
    - The Effluent Treatment Plants (ETP) and Sewage Treatment Plants (STP).

- The Continuous Ambient Air Quality Monitoring Systems (CAAQMS) that track air pollution.
- **Phase III: Interviews and Analysis :** We sat down for scheduled talks and technical briefings with the plant's operations managers, safety officers, and senior engineers. Finally, we turned our field notes into clear process maps to see how well the plant follows environmental laws.

Results :

Our field study and data analysis brought to light several key pieces of operational data regarding how the plant handles its waste streams:

1. Solid Waste Metrics & Ash Evacuation :

The plant has to process a huge amount of solid waste because it burns domestic Indian coal, which naturally contains 30% to 45% ash.

- **Fly Ash Generation & Extraction :** Around 80% of the total ash produced is fly ash. The plant catches these tiny particles out of the smoke using high-voltage, multi-field Electrostatic Precipitators (ESPs) [10]. These machines are highly effective, catching more than 99.5% of the dust. Once caught, air pressure pumps the dust through sealed pipes into closed storage silos so it cannot blow away.
- **Bottom Ash Handling :** The heavier ash and slag that falls to the bottom of the furnaces goes into water-filled hoppers. After it cools down, the water is drained out, and conveyor belts carry the wet ash to open storage bunkers.

2. Flue Gas and Fugitive Dust Suppression :

- **Cleaning the Smoke :** The plant uses continuous monitoring software to track air pollutants like $PM_{2.5}$, PM_{10}, SO_2, NO_x, and CO in real time. They also installed advanced Flue Gas Desulfurization (FGD) systems. This equipment mixes limestone with the smoke to turn dangerous sulfur dioxide gases into synthetic gypsum, which can then be sold to businesses.
- **Controlling Loose Dust :** To stop coal dust from blowing into the air, the plant uses completely covered conveyor belts and keeps coal inside enclosed storage sheds. They also use automatic mist cannons that spray high-pressure water during hot, dry days, and they regularly sweep the concrete roads with cleaning trucks.

3. Industrial Water Management Dynamics :

By early 2026, data showed the plant uses 2.21 m^3 of water per megawatt-hour (m^3/MWh). This is well below the maximum limit set by Indian law for inland power stations.

Unit / System	Processed Stream Details	Sustainability End-Use / Allocation
Effluent Treatment Plant (ETP)	Cleans regular industrial waste streams, coal yard rainwater runoff, and floor drains.	The cleaned water is reused to spray down dust and cool hot bottom ash.
Sewage Treatment Plant (STP)	Treats domestic wastewater coming from offices and canteens.	The treated water is used entirely to water the plant's internal forests and green lawns.

Discussion :

Our findings show that moving away from old wet ash ponds to modern dry ash systems cuts down environmental risks significantly. Keeping fly ash as a dry powder preserves its natural chemical qualities, making it highly valuable as a raw material for making cement [11].

A major success at this facility is their Ash Utilization Promotion & Research Park. This local research and industrial center connects a messy industrial byproduct directly with commercial buyers. By setting up testing labs and small assembly lines inside the park, the plant has speeded up local supply chains for three main uses: blending cement, filling ground space for road projects within 300 km, and supplying local businesses making fly-ash bricks [12].

Even though the plant has managed to reuse almost all of its ash recently, long-term problems still exist. Moving heavy ash over distances farther than 300 km costs a lot of money and hurts profit margins. To solve this geographic bottleneck, the region needs to build dedicated rail shipping networks that can move massive amounts of ash reliably.

Conclusion :

Our field study shows that, the Adani Power facility in Tirora works in a highly organized way to meet current CPCB guidelines and environmental laws. By using supercritical technology, the plant burns less coal and cuts down its baseline waste right from the start. Its combination of 100% dry pneumatic ash piping, total water recycling, and the creation of the Ash Park provides a practical blueprint for other heavy industries trying to cut down on waste.

To keep this progress going, we suggest the following policy and operational changes:

- **Stop Wet Disposal :** Fully shut down and dismantle any remaining wet ash slurry systems by 2027 to rely completely on dry handling.
- **Support Local Businesses :** Run free skill workshops inside the Ash Park to teach local residents how to start their own businesses making fly-ash bricks.
- **Public Digital Dashboards :** Link up IoT sensors and satellite images to create an online, public portal where anyone can view the plant's real-time pollution data.

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